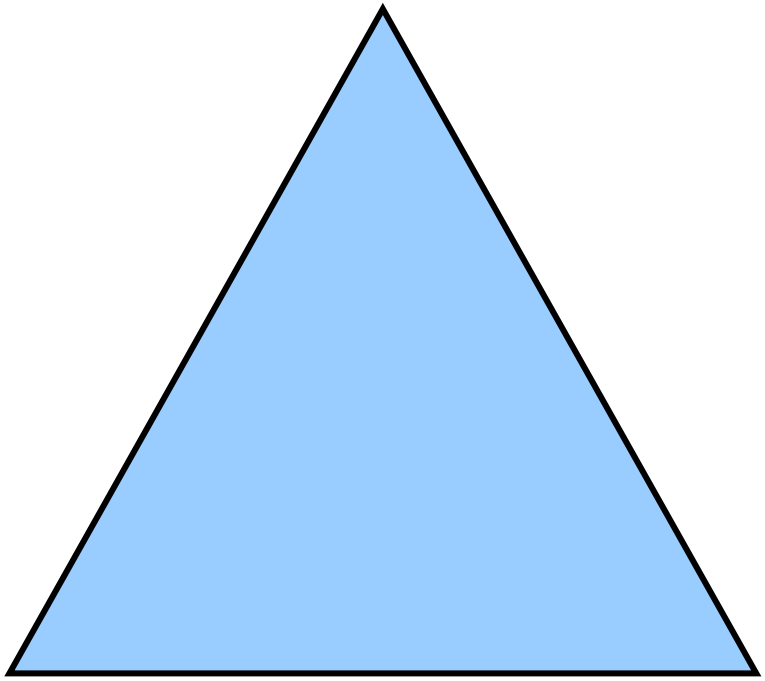
Interaction Techniques Using The Wii Remote
(and other HCI research)

Johnny Chung Lee
Microsoft - Applied Sciences
Carnegie Mellon University
Dec2008

What is HCI?

Psychology

Understanding People



CS/EE

Understanding Technology

Design

Understanding Needs

Interaction Techniques Using The Wii Remote
(and other HCI research)

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Nintendo Wii

Nintendo's 5th Video game console
Release Date: 11/19/06
35 million units worldwide (Sept '08)

>35 million Wii remotes

1-4 remotes per console

7-10 million Tablet PCs

Nintendo Wii Remote

Bluetooth HID compatible joystick
MSRP $40 USD

Inputs:
IR camera tracker
Accelerometer
12 digital buttons

Outputs:
Tactile – vibration motor
Auditory – small speaker
Visual –blue status LEDs

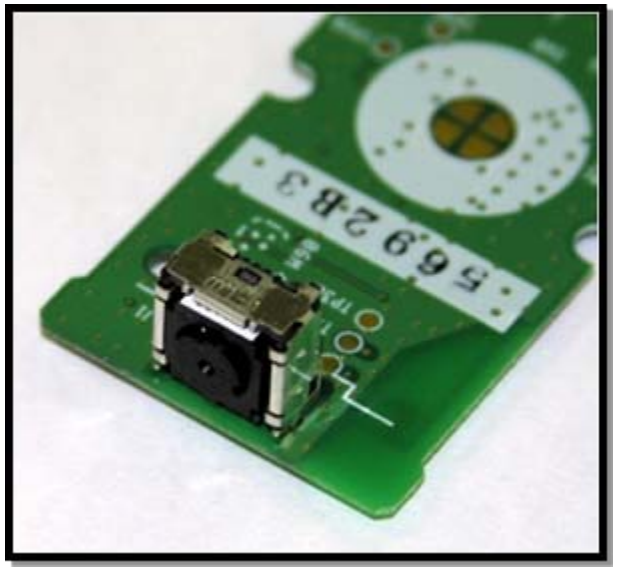
Other:
Expansion port
On-board memory
Batteries

IR Camera Tracker

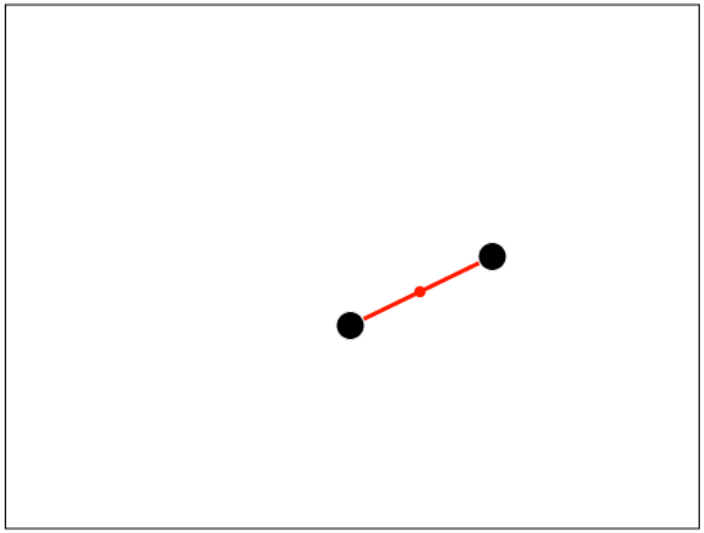
Manufactured by PixArt Imaging
Multi-Object Tracking™ engine (MOT sensor™)

Official specifications are confidential, but….

Hardware IR blob tracking up to 4 points
Resolution: 1024x768 (true: 128x96)
Refresh Rate: 100Hz – 200Hz via I2C
Dot size: 4-bits
Intensity: 8-bits
Bounding Box: 7-bits x-y
Horizontal Field of view: 45 degrees



Nintendo Wii “Sensor Bar”



Contains two IR emitter groups

Two dots = 4 values: (*x1*, *y1*), (*x2*, *y2*)

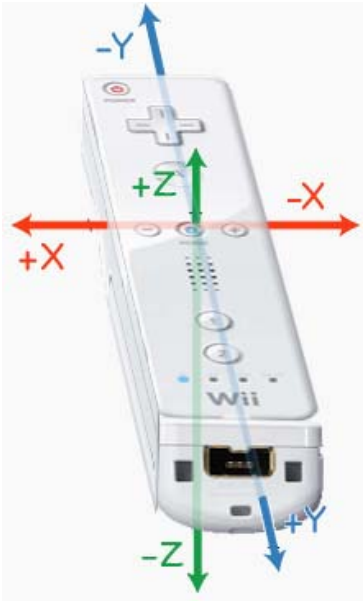
4 values → ***x***, ***y***, ***rotation***, and ***distance***

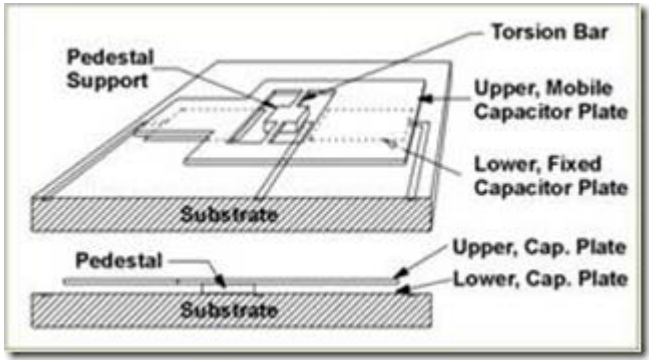
correspond primarily to: *tilt*, *yaw*, *roll*, and *distance*

Accelerometer

Analog Devices (ADXL330)

3-axis linear accelerometer
Range: +/-3g sensitivity
Resolution: 8 bits/axis
Sample Rate: 100Hz





Buttons

Total of 12 digital buttons
11 are accessible to an application

Power button - initiates and terminates Bluetooth connection

Ambidextrous design
4 buttons arranged in a D-pad

Index finger trigger button (B)
Primary thumb button (A)

Output

Tactile – Vibration motor, up to100Hz update rate

Auditory – Small speaker, 4Khz*, 4-bit audio streamed from host, approx telephone quality.

Visual – Four blue LEDs, player ID, individually addressable, up to100Hz update rate

Other Features

Bluetooth – Broadcom 2042 for Human Interface Devices (HIDs). Not 100% compliant, but compatible with PCs.

Expansion Port – Proprietary 6-pin connector. Provides power and Fast I2C communication. Acts as a Bluetooth to I2C bridge.

Onboard Memory – device configuration and ~ 5KB of general memory. Physical association of data and identity with a remote.

Batteries – two AA batteries provide 20-30 of operation. 8-bit battery level sensor.

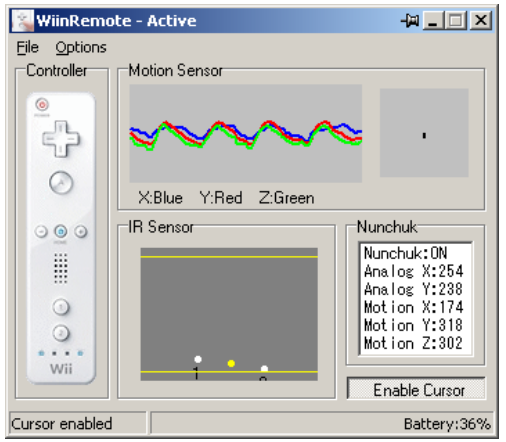
Developing Custom Applications

Bluetooth HID joystick compatible with HID driver libraries.

Libraries available for nearly every major development platforms on Windows, MacOS, and Linux.

Visit http://wiili.org or http://wiibrew.org

Brain Peeks C# managed WiimoteLib
Read values from data structure to access data
Most libraries include a sample program



Eventual support:

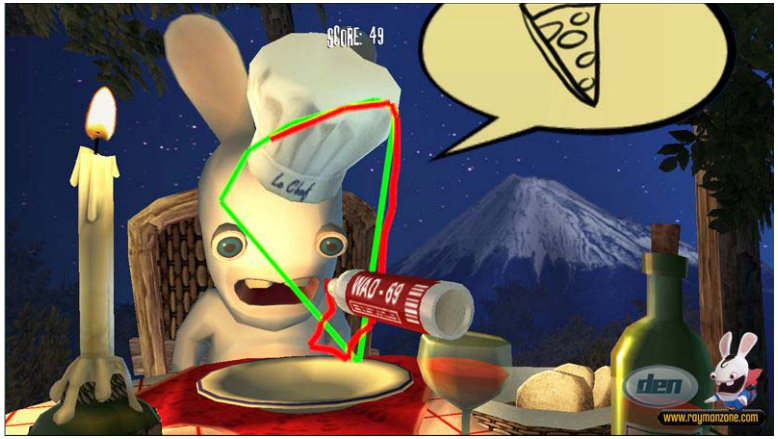
- Better Event-handling
- Related geometric transformations
- Gesture Recognition

Interaction Techniques

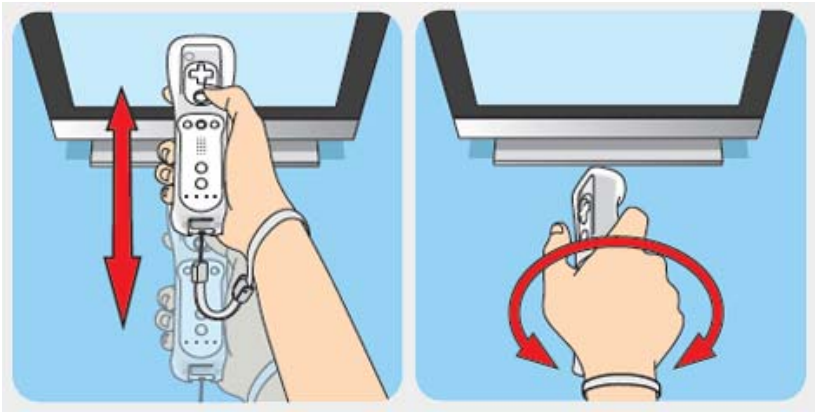
Game Interaction – Pointing

Selection/Navigation

Aiming a weapon/tool



Drawing



Push/Pull or Rotate

Note: All pointing is relative

Game Interaction – Motion

Directional Shake Trigger

Analog Shaking

Tilt Control

Swing Simulation

Games provide context on how to hold remote.

Game Interaction – Buttons and Joysticks

Nunchuk attachment
for non-dominant hand

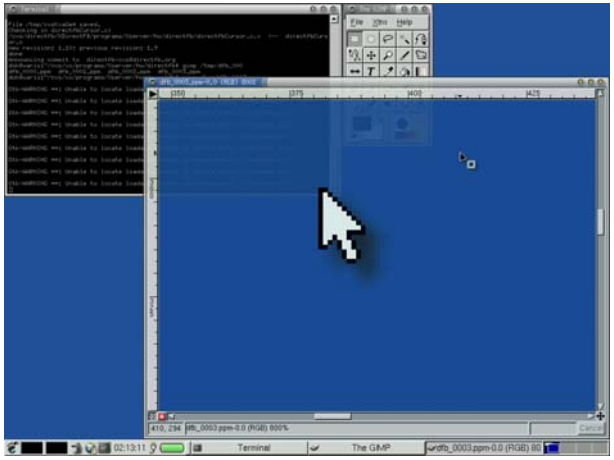
Joystick
2 buttons
3-axis accelerometer

Input Device	Digital	Analog
Wii Remote + Nunchuk	13	12
Xbox 360 Controller	14	6
Scroll Mouse	3	3

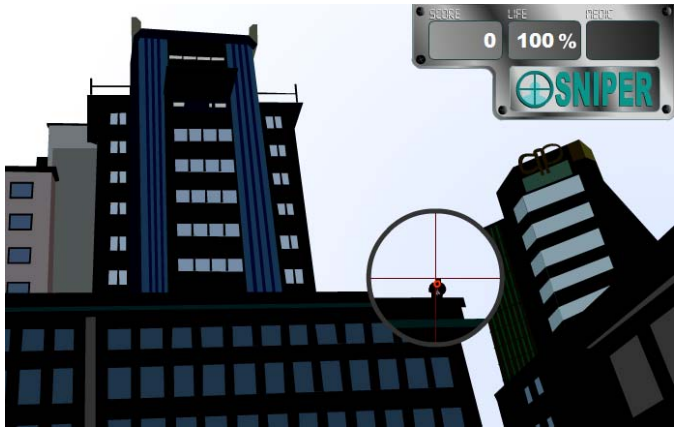
By the Developer Community

Robot Control

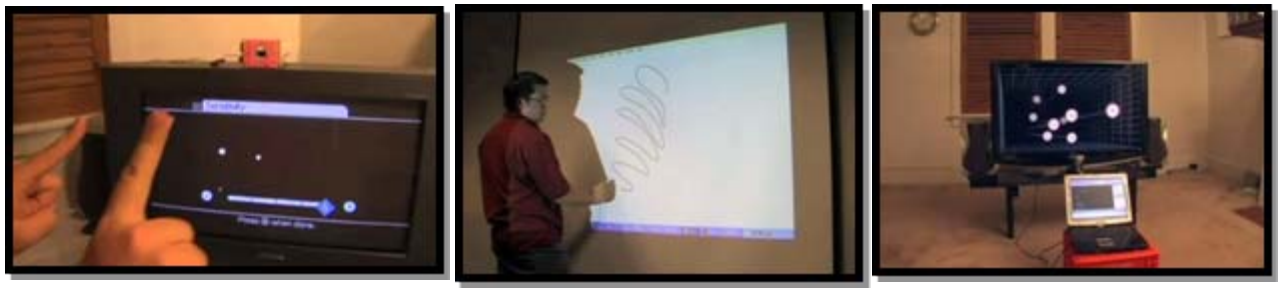
Synth Music Performance



Cursor Control

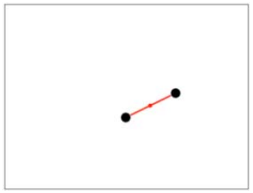


Flash-Based Mouse Games



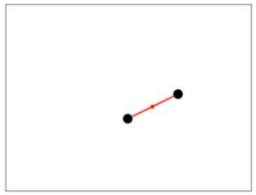
Online Videos Tutorials
>10 million views

Moving + **Stationary** = **Orientation**



tilt, ***yaw***, ***roll***, and ***z***

Moving + **Stationary** = **Translation**

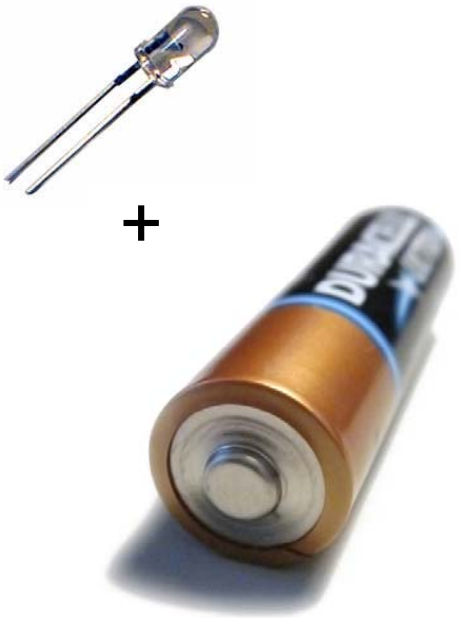


x, ***y***, ***z***, and ***roll***

project 1

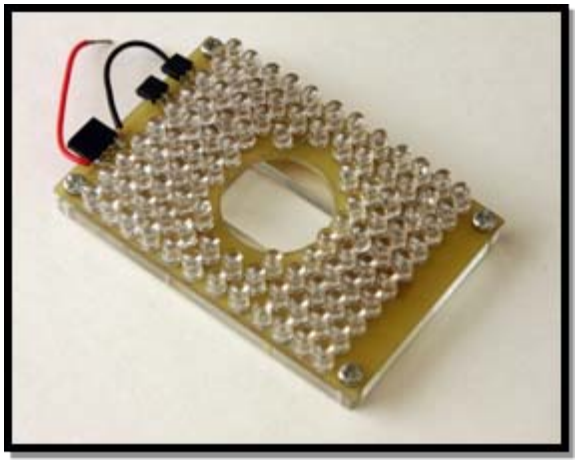
Finger and Object Tracking

Finger and Object Tracking



Wii remote can track any IR emitter
Active emitters can be cumbersome

Finger and Object Tracking



Vicon Motion Capture System

Video – Finger Tracking

Object Tracking - Limitations

Only 4 points – limitation of Wii remote, but good for the price. Temporal multiplexing, multiple remotes

No inactive cursor feedback → 4 point index finger and thumb tracking with pinch detection.

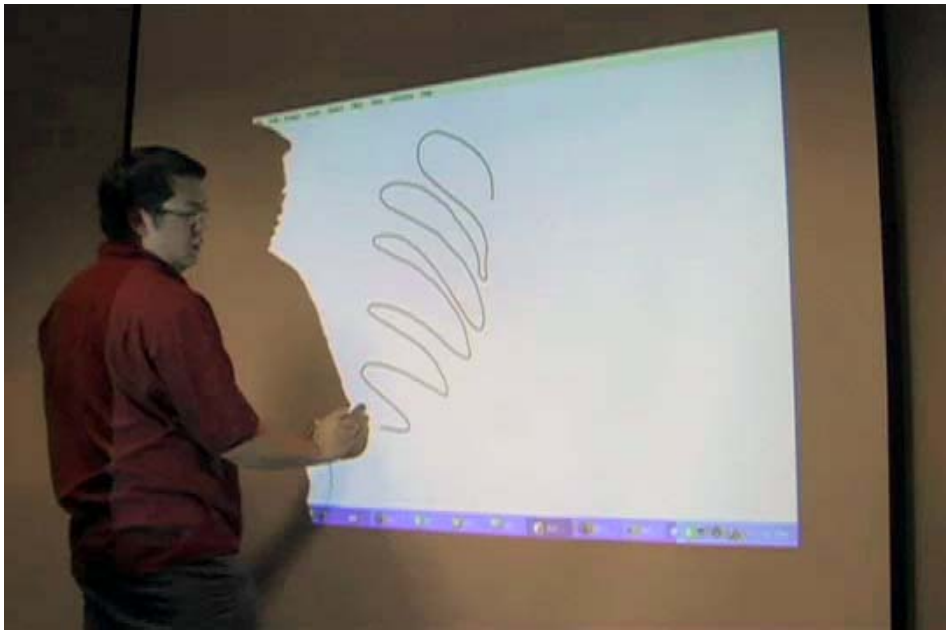
Arm Fatigue → Table top or transparent surfaces. Reflective tags may need repositioning.

Unintentional Reflections → Active IR emitters when possible. Can be installed in handheld or wearable devices (e.g. sports equipment, animal tracking).

project 2

Interactive Whiteboards

Multi-Point Interactive Whiteboards



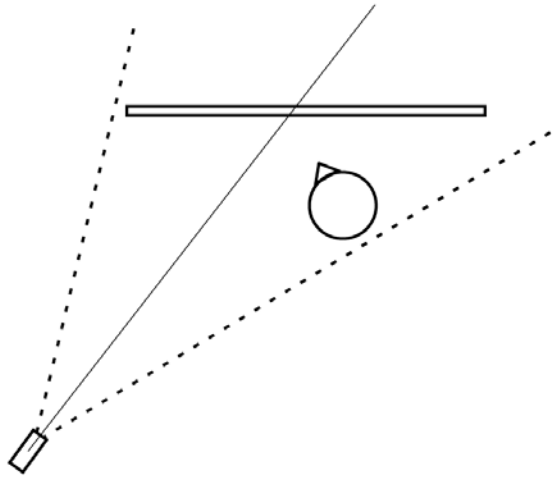
Point Wii remote at display
Map camera coordinates to display coordinates
4-point touch calibration (homography)
Simulate mouse cursor

Effective electronic whiteboard system for **$50**

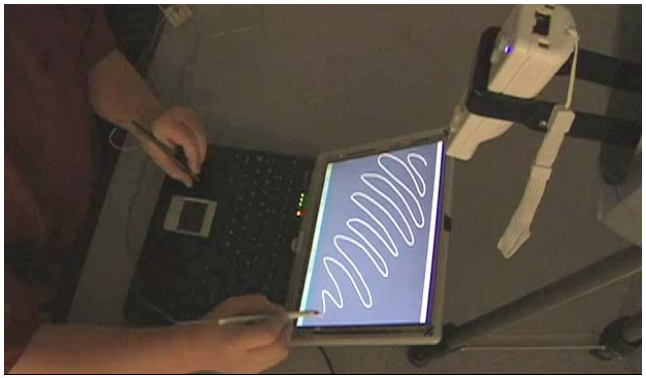
Video/Demo – Whiteboard

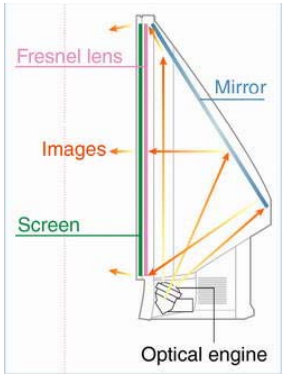
Interactive Whiteboards - Limitations

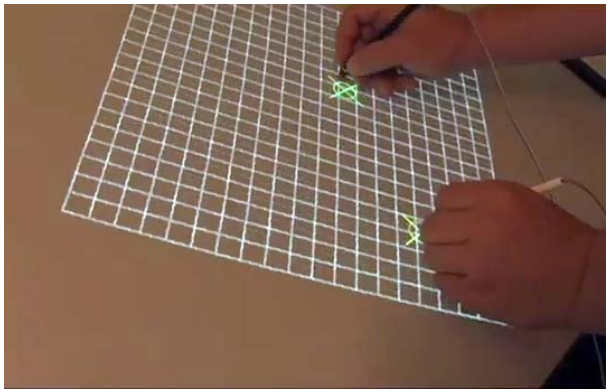
Maximum 1024x768 resolution.
Dependent on good camera positioning.
Sensitive to occlusion.



Solutions
Adjust camera position (over-head)
Use multiple Wii remotes
Use rear projected displays.

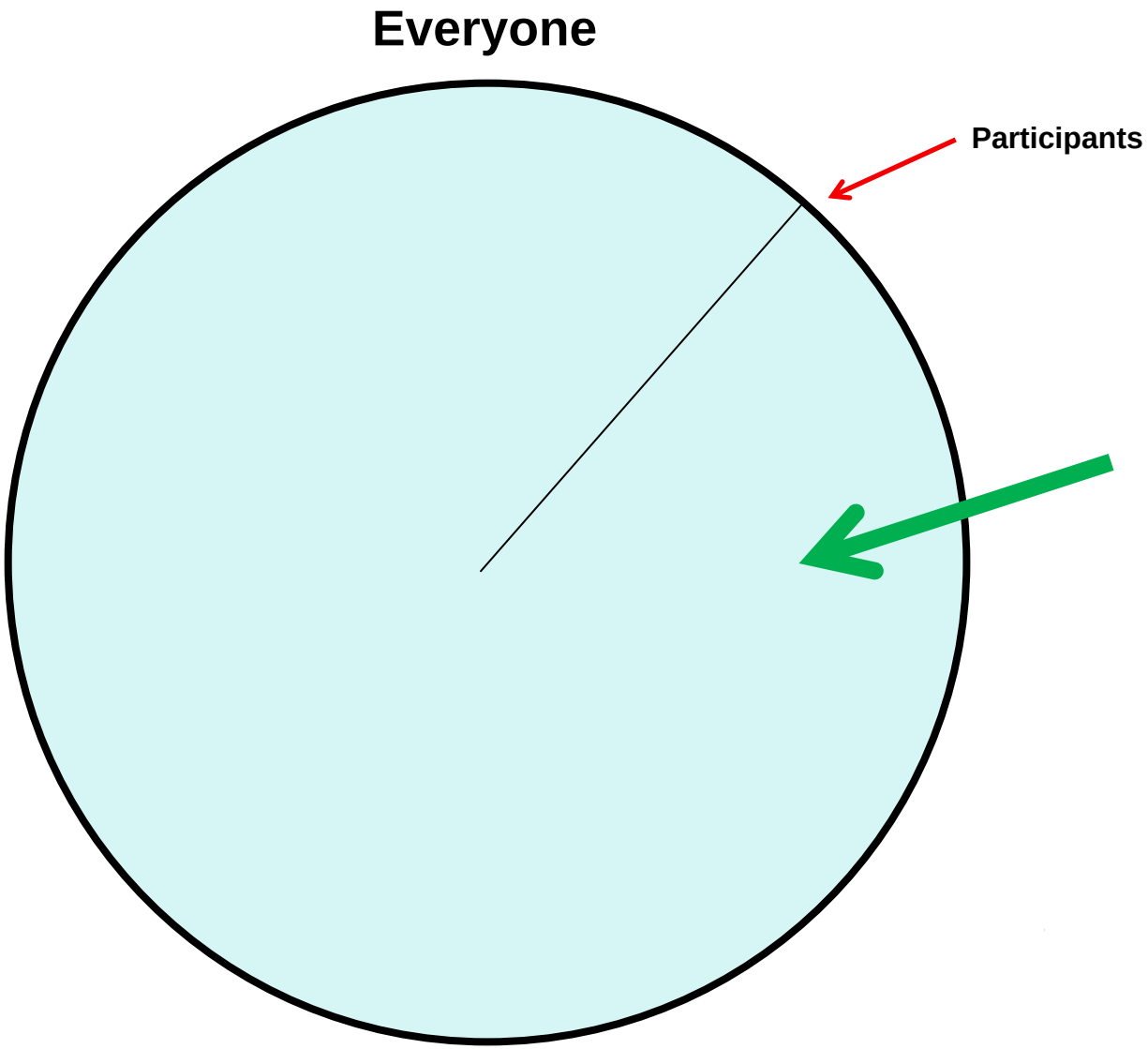






80% of the way there

1% of the cost


Everyone
Participants

HCII

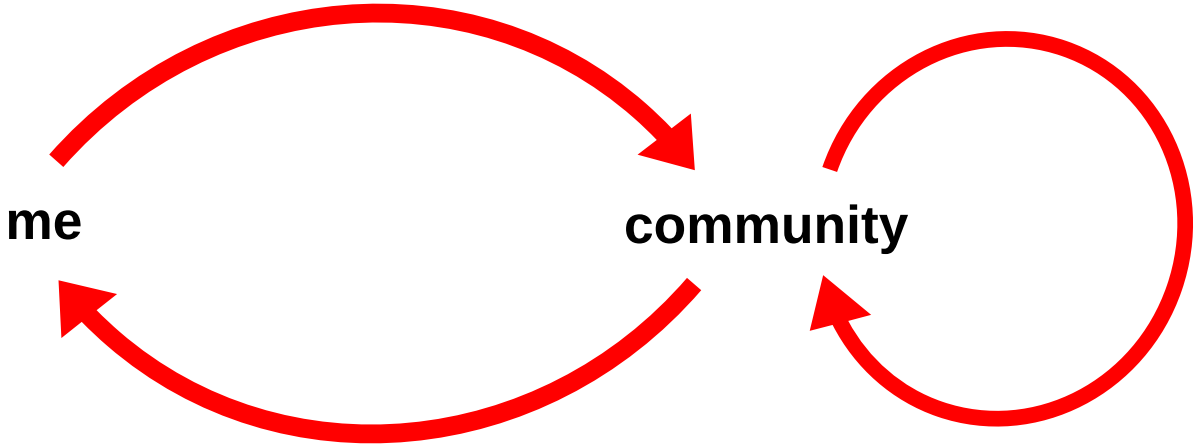
Two Effects:

1. **Increased participation:**
   Advances the state of research

2. **Increased practicality:**
   Advances the state of technology

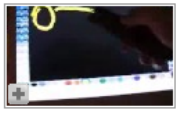
YouTube™

>2 million views



Video Responses (37 Responses)

Play All Video Resp



[Re: Low-Cost Multi-touch](#)
From: wiibart
Views: 340
Response : 37
05:34 ★★★½☆
Remove

[Wiimote + Infra-red pen = a brea...](#)
From: techsavvy4sc...
Views: 567
Response : 36
02:29 ★★★★½
Remove

[Re: Low-Cost Multi-touch](#)
From: yurukov
Views: 1,500
Response : 35
06:46 ★★★★★
Remove

[My Wiimote "Smartboard"](#)
From: lolerd
Views: 1,274
Response : 34
03:00 ★★★★½
Remove

[Wiimote whiteboard on projector](#)
From: xaanaax
Views: 250
Response : 33
02:00 ★★★★★
Remove

[My Wiimote Whiteboard beta](#)
From: acosta11
Views: 1,881
Response : 32
01:42 ★★★★☆
Remove

[Re: Low-Cost Multi-touch](#)
From: TheCEO54
Views: 12,243
Response : 31
08:47 ★★★½☆
Remove

[Wii Remote Whiteboard 4th](#)
From: parkerdet
Views: 6,900
Response : 30
01:58 ★★★★½
Remove

[wii remote laser tracking](#)
From: sha433
Views: 13,759
Response : 29
02:05 ★★★★★
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[Cheap Whiteboard with a wiimote](#)
From: DJTx1300
Views: 4,948
Response : 28
03:16 ★★★★☆
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[Playing Football on Screen](#)
From: vgaliano
Views: 1,471
Response : 27
01:40 ★★★½☆
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[WiimoteWhiteboa rd Java Implemen...](#)
From: ujs83
Views: 4,385
Response : 26
00:44 ★★★★★
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[HOWTO build an IR pen](#)
From: choulo
Views: 35,778
Response : 25
03:58 ★★★★½
Remove

[Re: Low-Cost Multi-touch](#)
From: albes83
Views: 2,202
Response : 24
00:37 ★★★★☆
Remove

[Edusim (Powered by Croquet) on u...](#)
From: GreenbushTV
Views: 4,862
Response : 23
01:31 ★★★½☆
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[Re: Low-Cost Multi-touch](#)
From: Haprog
Views: 4,559
Response : 22
00:56 ★★★★½
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[Wiimote Whiteboard vs. Commercia...](#)
From: drew0mckinney
Views: 25,735
Response : 21
05:49 ★★★★★
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[Re: Low-Cost Multi-touch](#)
From: TrabBurks
Views: 4,331
Response : 20
05:33 ★★★★★
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[Re: Low-Cost Multi-touch](#)
From: Bmud
Views: 1,407
Response : 19

[Re: Low-Cost Multi-touch](#)
From: hagenees80
Views: 3,212
Response : 18

[Wii Whiteboard with Projector](#)
From: ignoble
Views: 2,084
Response : 17

[Wii Whiteboard with LCD](#)
From: ignoble
Views: 4,005
Response : 16

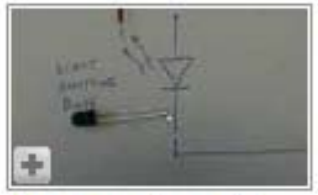
[Re: Low-Cost Multi-touch](#)
From: Speckknoedel
Views: 1,825
Response : 15

[Touchscreen with Wiimote (Johnny...](#)
From: liransr
Views: 10,802
Response : 14

HOWTO build an IR pen

Added: 7 months ago
From: choulo
Views: 35,712
03:58

More in Science & Technology



How to make an IR pen for a Wiimote

Added: 7 months ago
From: ccardew
Views: 13,389
03:42

More in Education

IR PEN for wiimote

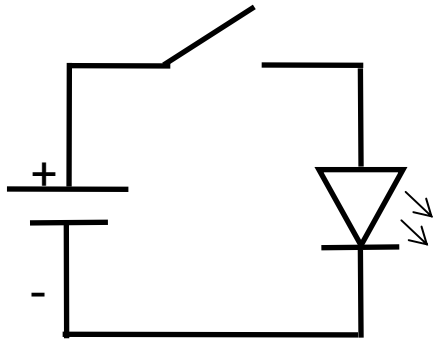
Added: 4 months ago
From: ay1066
Views: 1,416
02:24

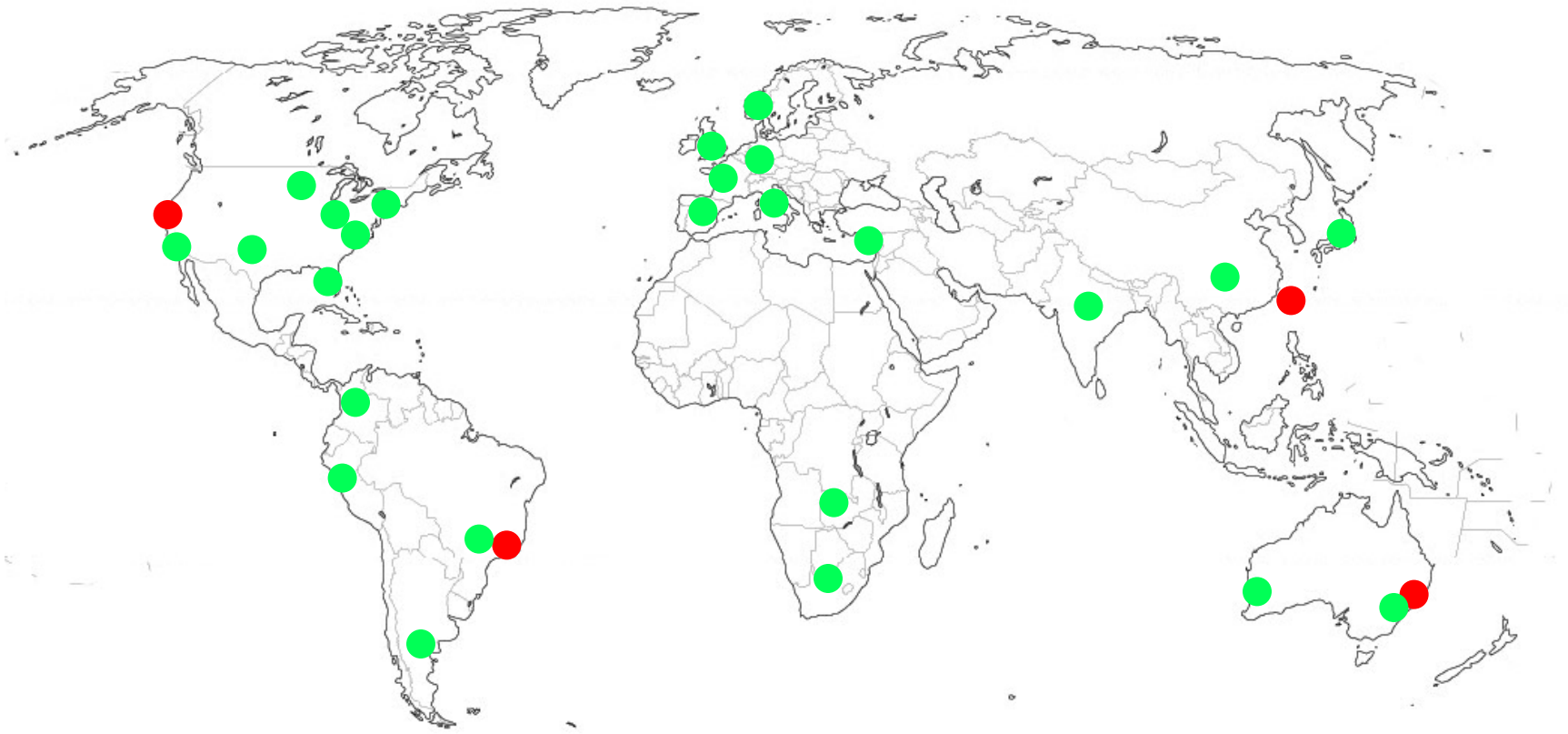
More in Howto & Style

Very Easy to Make! IR-Pen for Wiimote

Added: 2 months ago
From: benpaddlejones
Views: 983
04:31

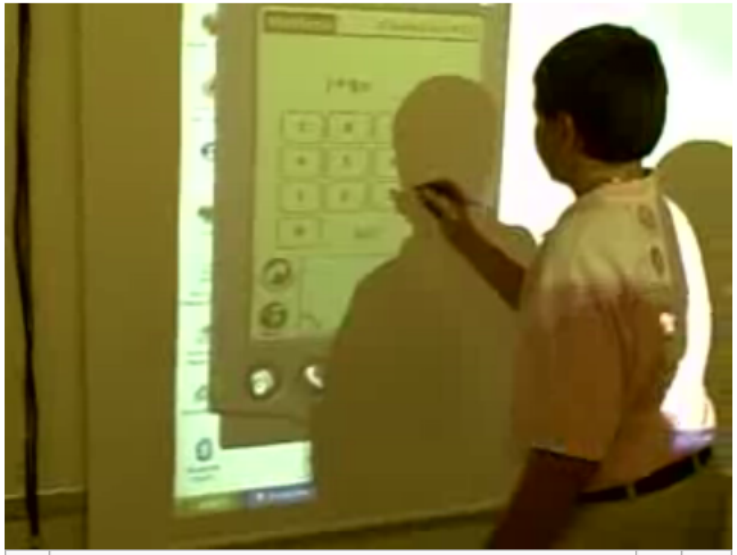
More in Howto & Style





HCII

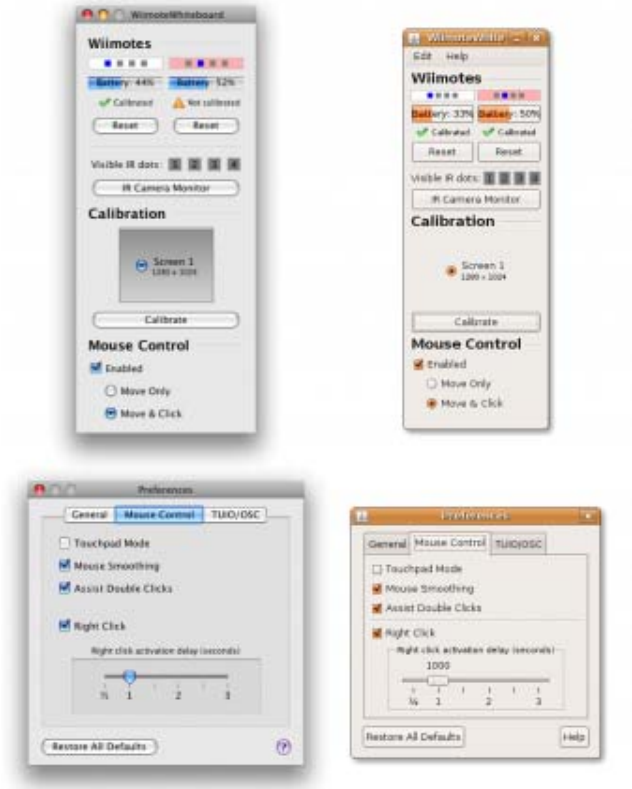
Students Using Wiimote Whiteboard



Students Using Wiimote Whiteboard

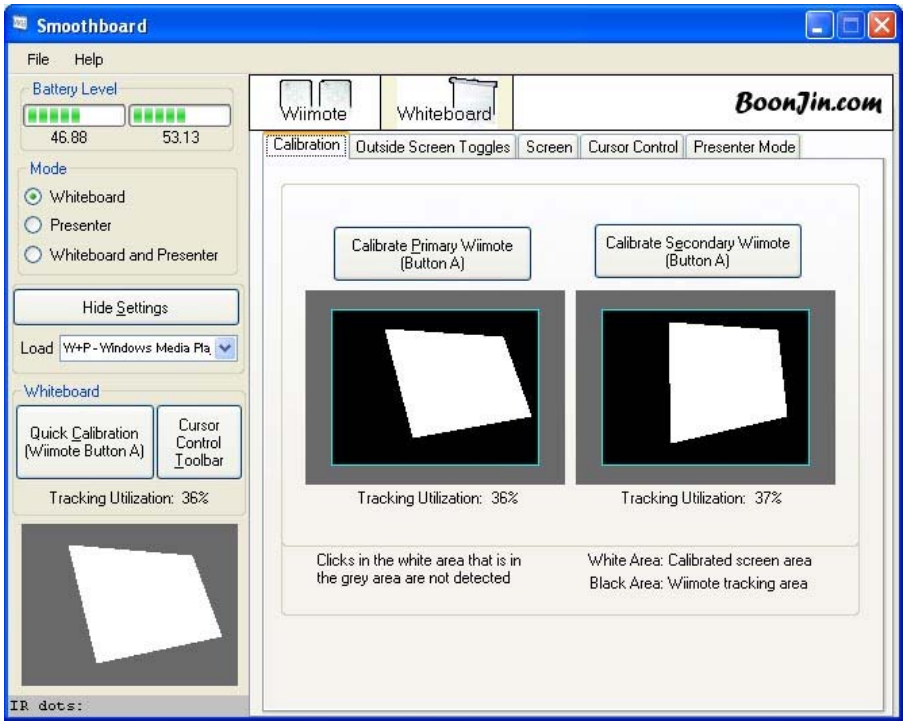
watch in high quality

HCII



Mac OS X

Linux



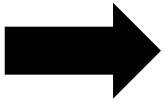
YoungHyun Chung, NYU

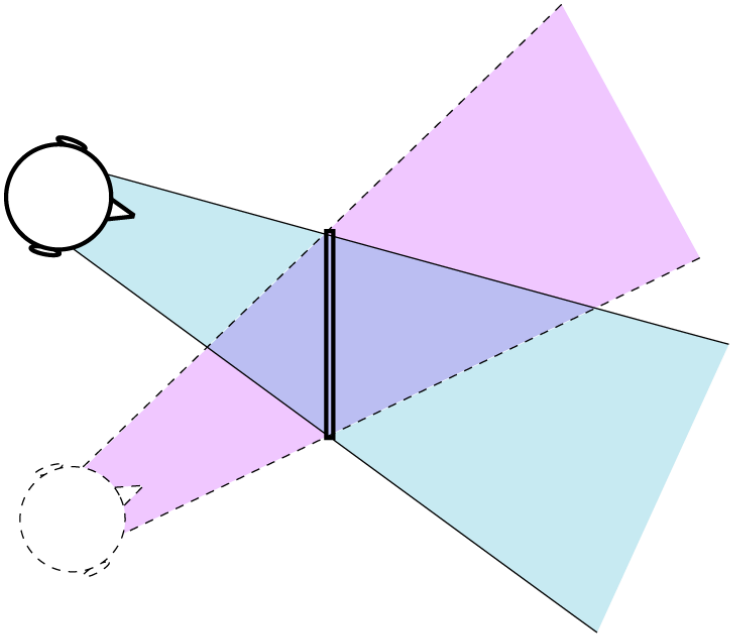
Optoma

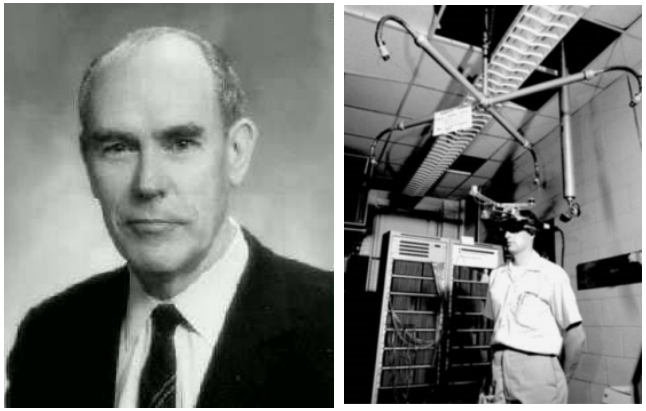
HCII

project 3

Head Tracking for Desktop VR

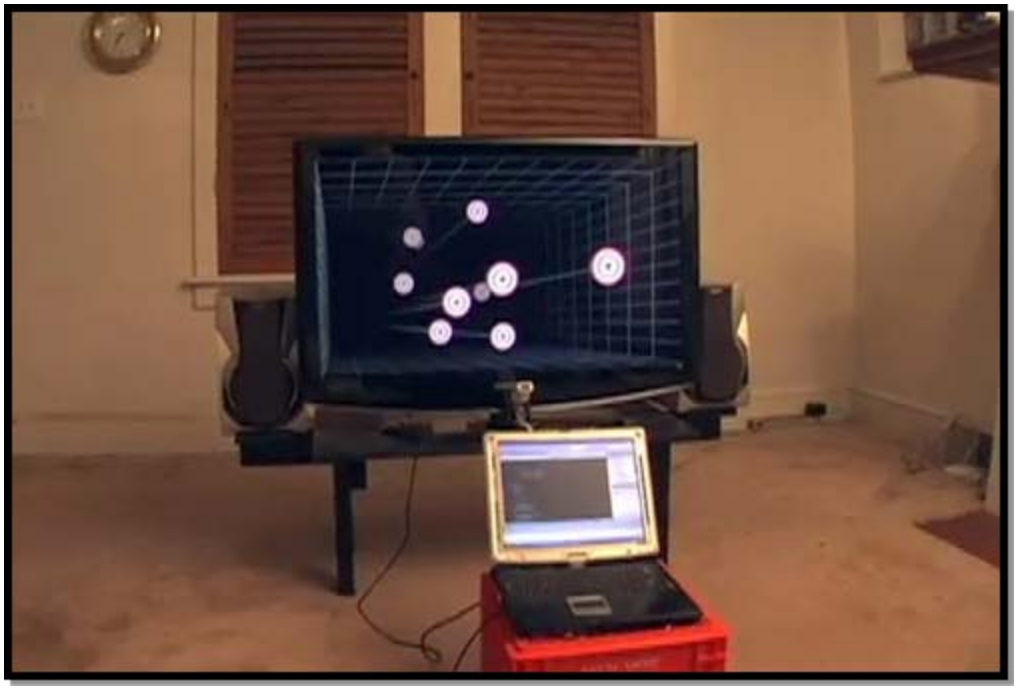




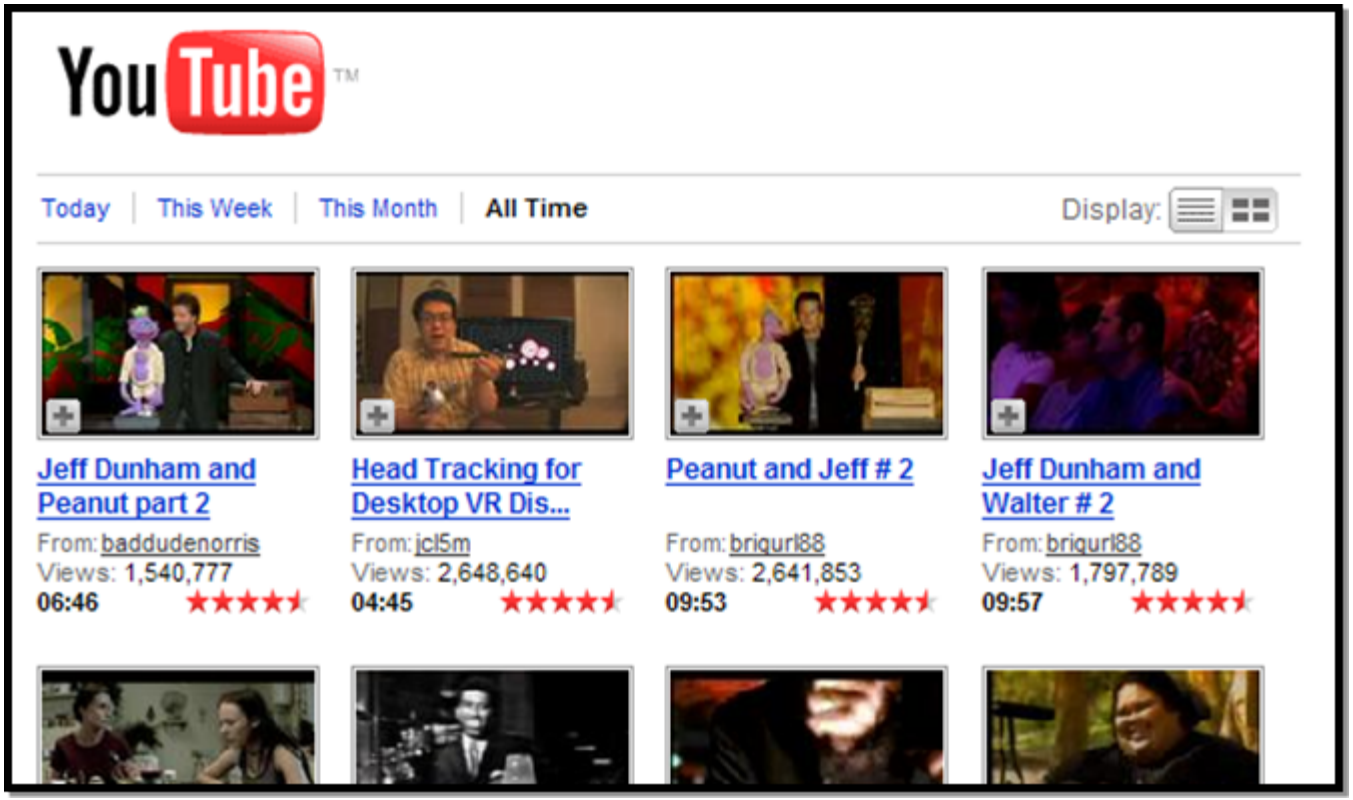


Ivan Sutherland, Harvard University, *c.* 1967.

HCII



Video/Demo – Head tracking

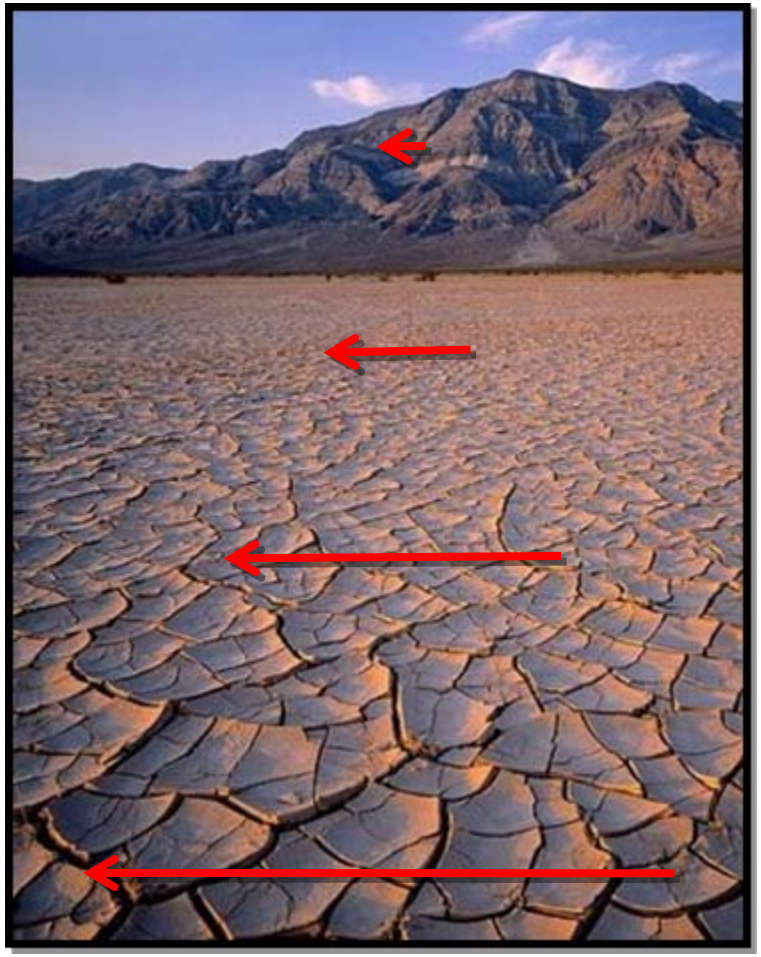

YouTube™
Today | This Week | This Month | All Time
Display:
Jeff Dunham and Peanut part 2
From: baddudenorris
Views: 1,540,777
06:46
Head Tracking for Desktop VR Dis...
From: jcl5m
Views: 2,648,640
04:45
Peanut and Jeff # 2
From: briqurl88
Views: 2,641,853
09:53
Jeff Dunham and Walter # 2
From: briqurl88
Views: 1,797,789
09:57

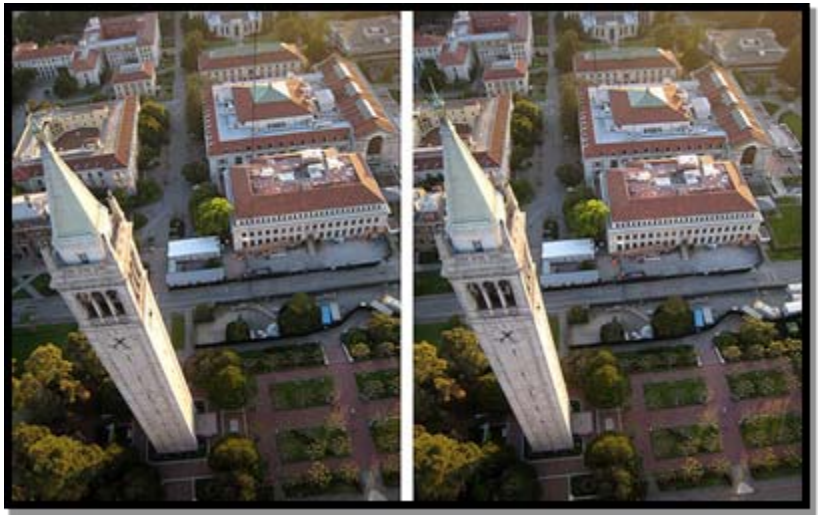
Head Tracking for Desktop VR Displays using the WiiRemote

Rate: ★★★★★ 22,918 ratings **Views:** 6,415,968

6 million ~= sold out shows 5 times a week for 10 years

Motion Parallax





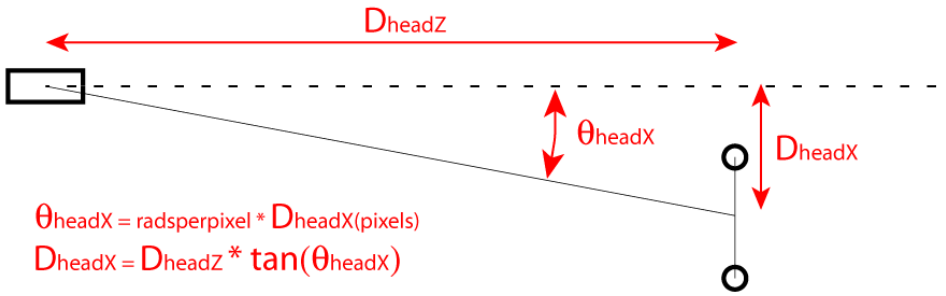
www.flickr.com/photos/kap_cris/472159801/

- Very important depth cue
- Velocity of objects when moving
- Occlusion behavior

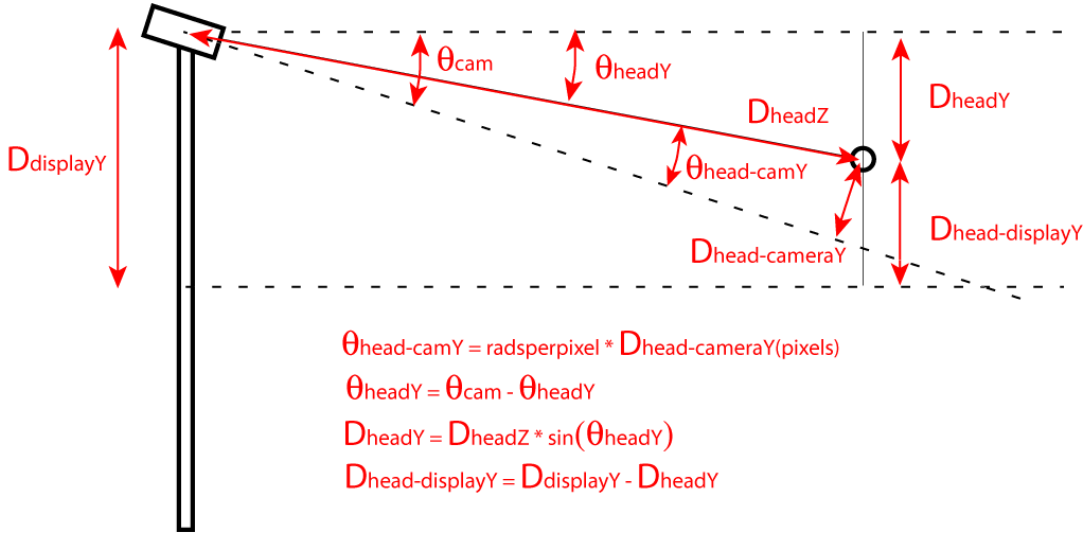
[Ware, Arthur, and Booth CHI'93]
Motion parallax is more important than stereo

Calculating Head Position

Horizontal Position



Vertical Position



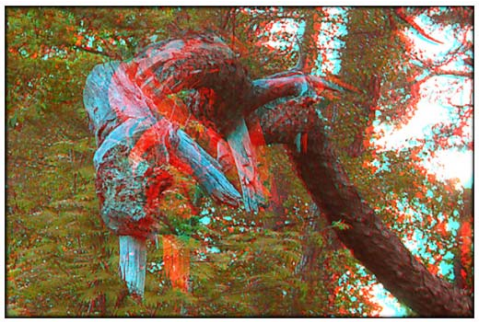
Limitations

Perspective is correct for only 1 person – split screen or shutter glasses

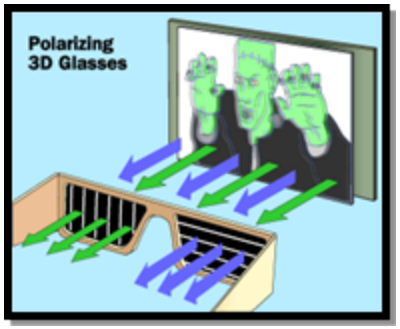
Limited Tracking Volume – increase field of view with wide angle lens or use multiple remotes.

Can't touch objects – Sorry. Keep objects behind the display surface and blame the display.

Conflicting Stereo Depth Cues – weakens the effect, use stereoscopic display technology (polarized/shutter glasses, etc)

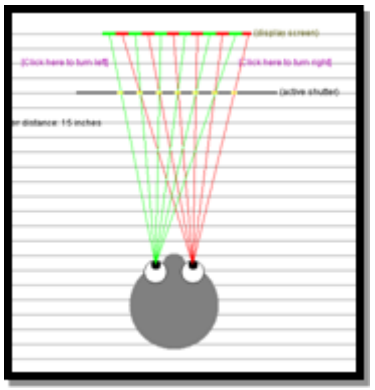


Anaglyph (red/blue): bad color fidelity, but would work, cheap



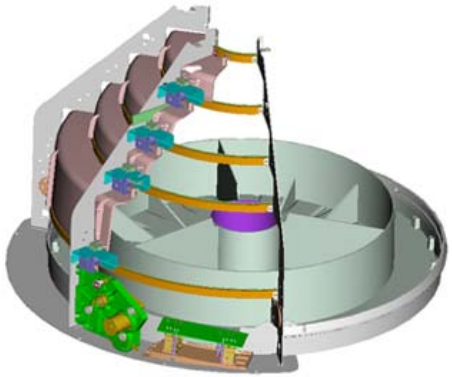
Polarized glasses: does not work with most existing consumer televisions, cheap

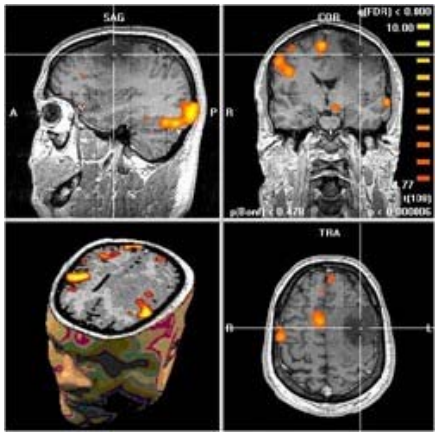
Shutter glasses: active device, frame sync, higher frame rates (120Hz okay)



Auto-stereoscopic:
not consumer technology yet

If you can’t provide stereo, removing the conflicting stereo depth cues **will improve** the head tracking illusion.

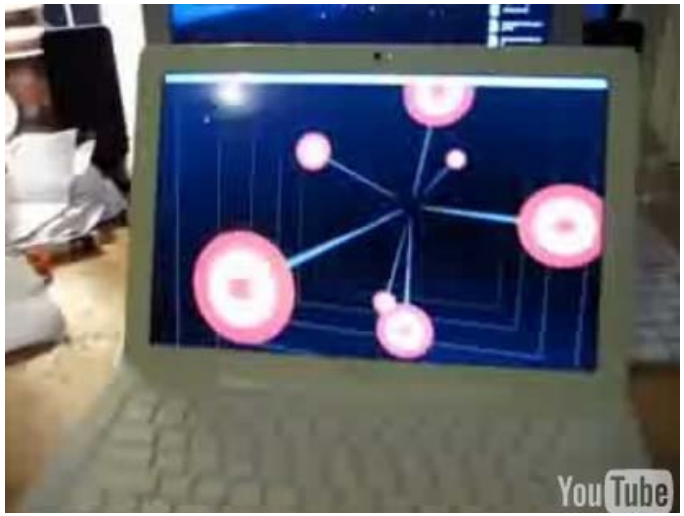



SAG
COR
TRA

BOOM
BLOX

Nigel Tzeng – NASA Whirlwind

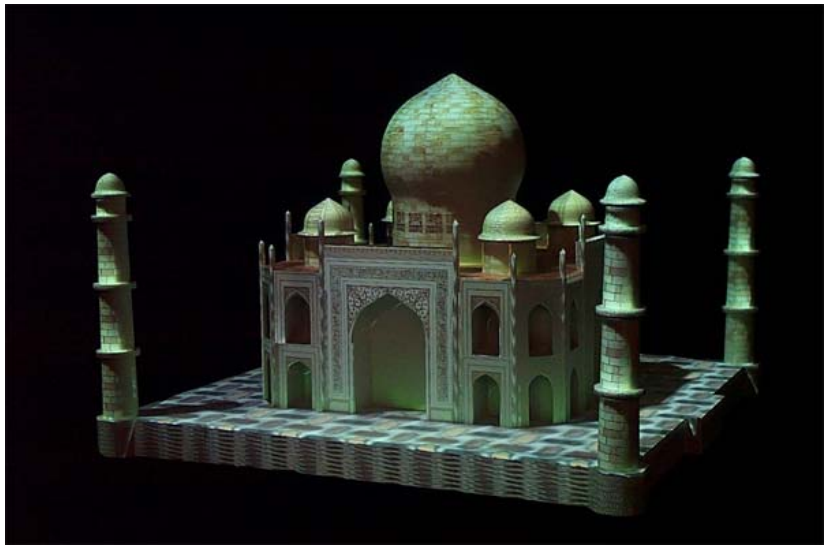
PLAYSTATION


YouTube

project 4

Spatial Augmented Reality

Spatial Augmented Reality



Shader Lamps, Raskar et al UNC/MERL

Everywhere Displays, Pinhanez et. al, IBM

Projected light can be used to augment the appearance of physical objects.

Aligning to static objects can be done manually.
Moving objects requires low-latency, high-resolution tracking.

1024x768 @ 100Hz tracking of the Wii remote is quite good.

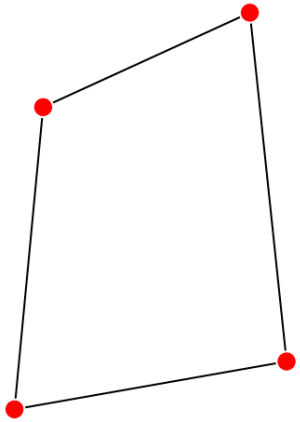
Video – Foldable Displays

Limitations

Wii remote only tracks 4 points.

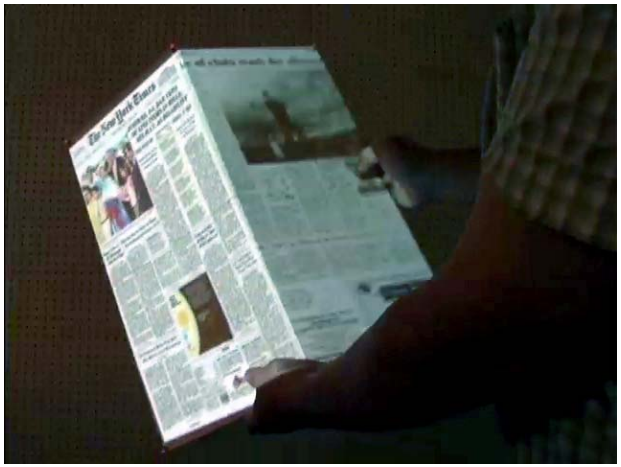
- Limits the number of objects
- Limits the geometric complexity

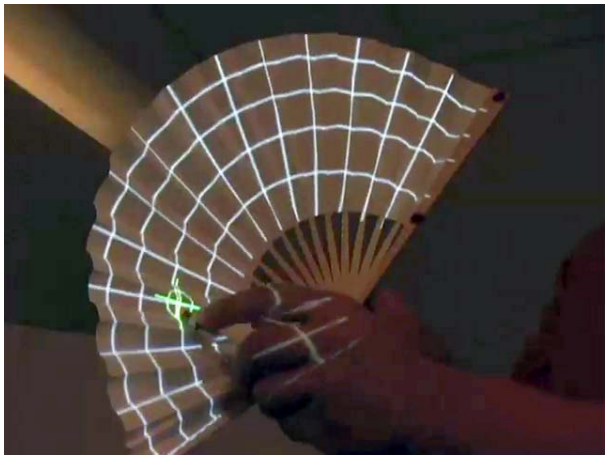
4 points can track arbitrary quadrilateral



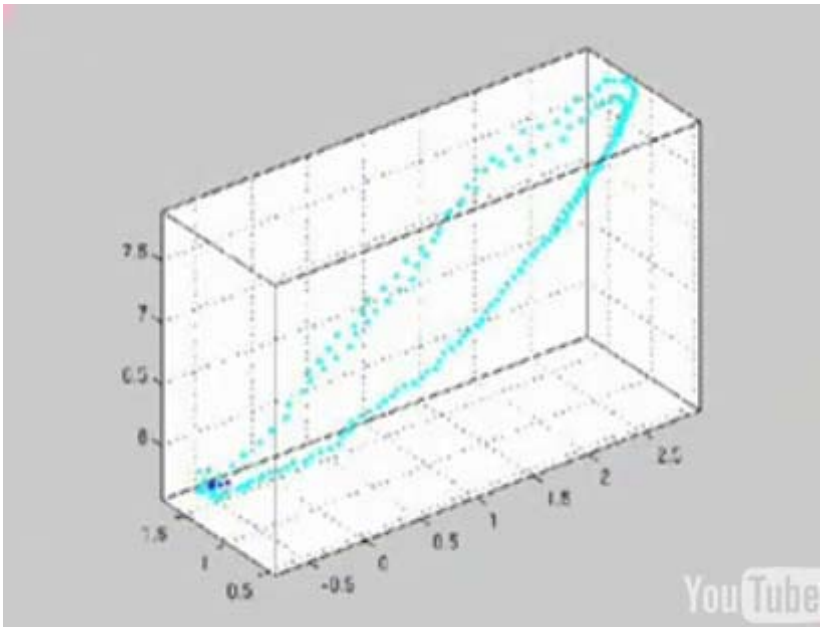
Assumptions reduces necessary points

- square surface
- constrained to a plane





Other projects: 3D tracking



Simon Hay, University of Cambridge

Other projects …

Tracking with ID – currently no point ID. Use high-speed IR receiver in conjunction with camera should allow location with ID.

IR Glyphs – use varying spatial and temporal behavior of 4 IR emitters to create unique IDs. Allows Wii remote to know what object it is pointing at.

Laser Tag – instrument each Wii remote with IR emitters so they can see each other. ID can be temporally verified.

Wii remotes

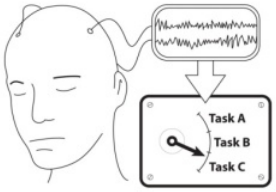
>35 million Wiimotes
Sophisticated I/O capabilities
Only $40 USD

Vast number of applications
limited only by creativity

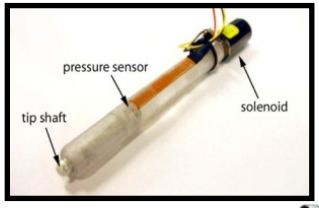
Document & Share
> 10 million views
> 700,000 downloads
1000s of students and teachers
8 patent licensees
6 major game studios
Exploring educational initiatives

Other HCI Research

Projector-Based Location Discovery and Tracking



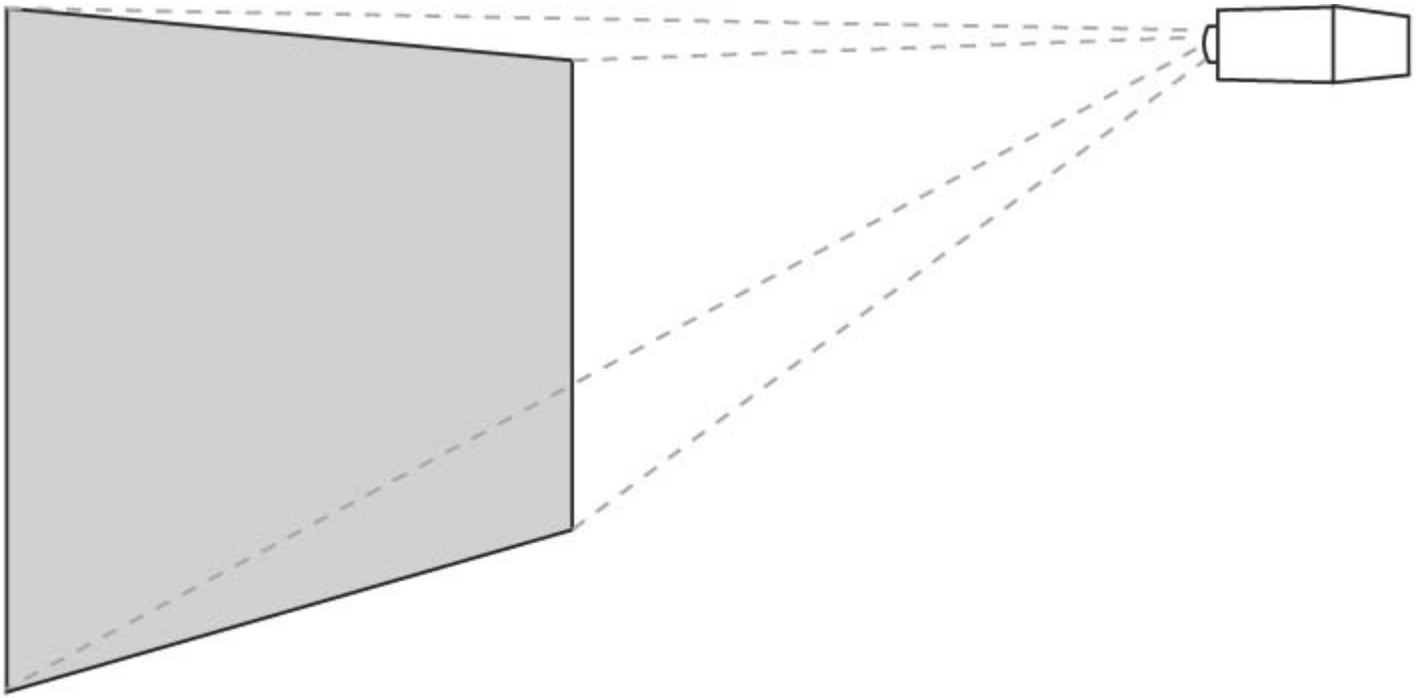
Low-Cost EEG for Task Classification



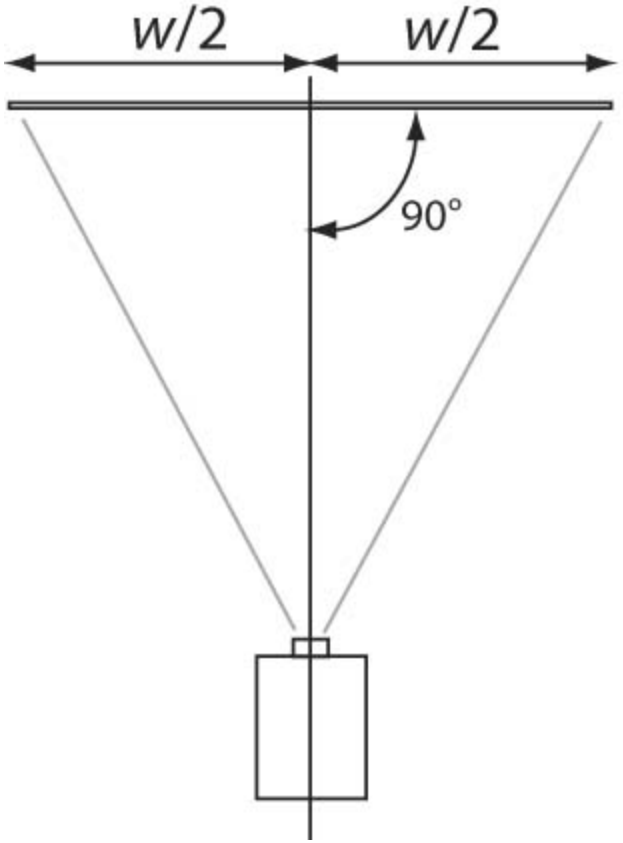
Haptic Pen

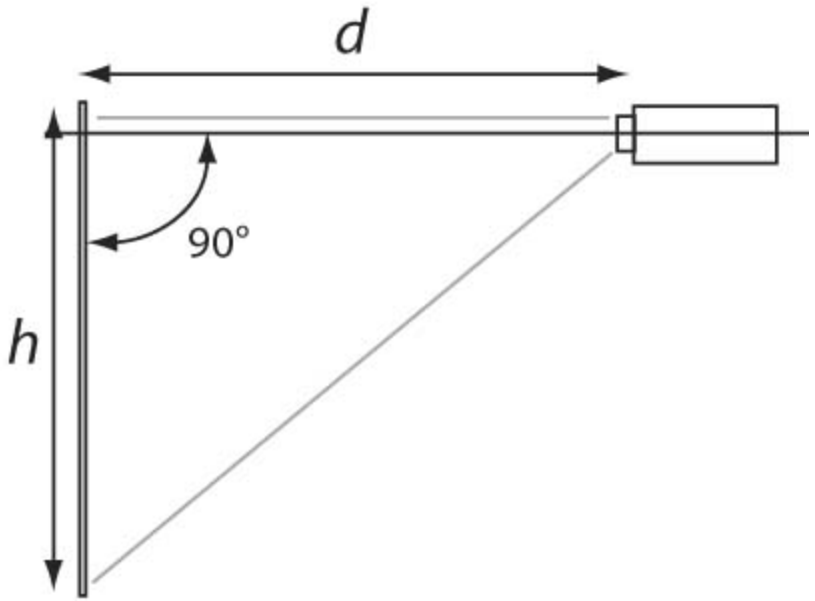
$14 steadycam

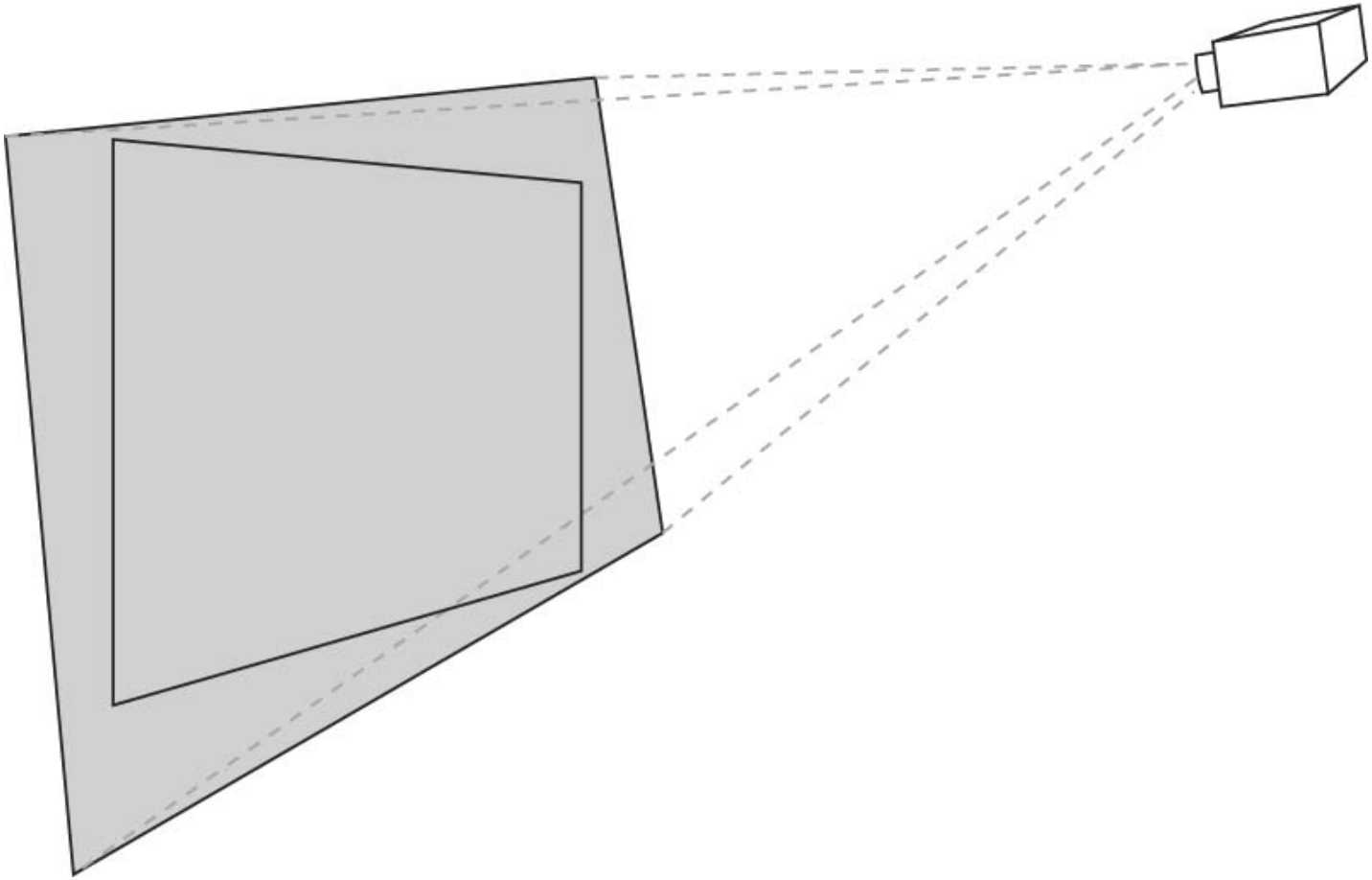
Projector-Based Location Discovery



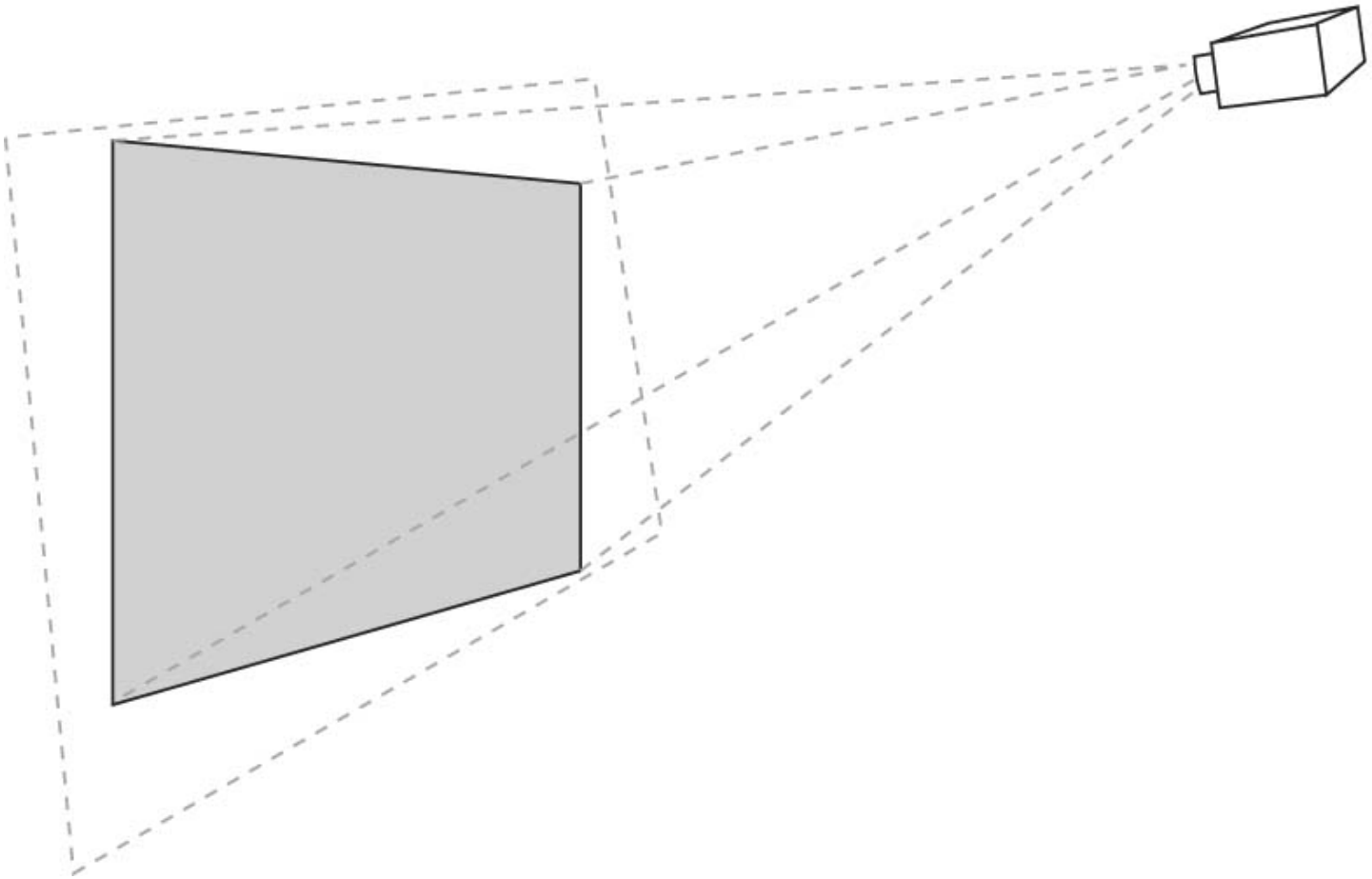
HCII


w/2
w/2
90°


d
90°
h

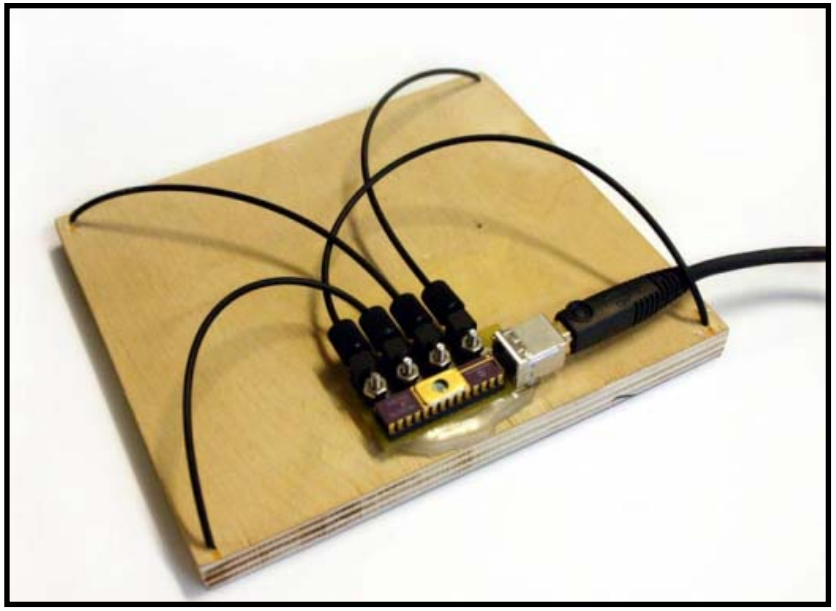


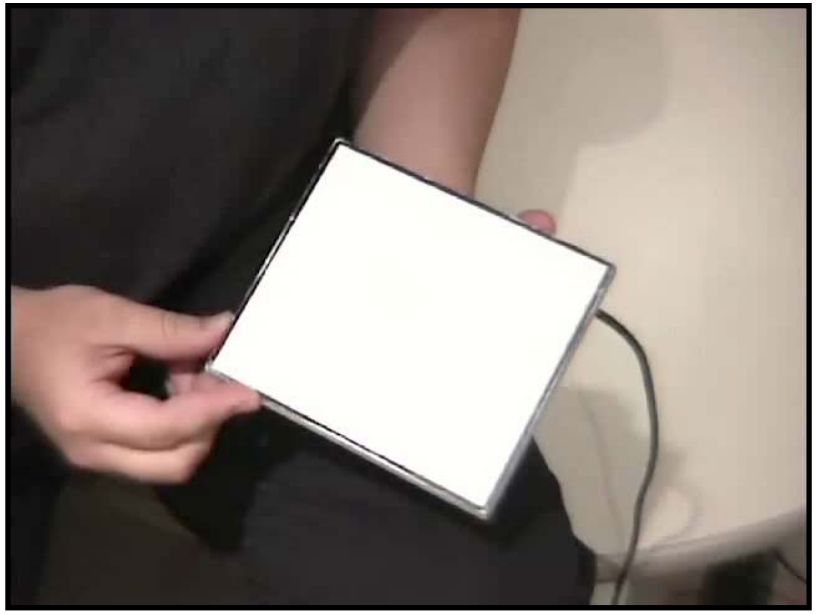
HCII



HCII

Step 1:
Embed light sensors

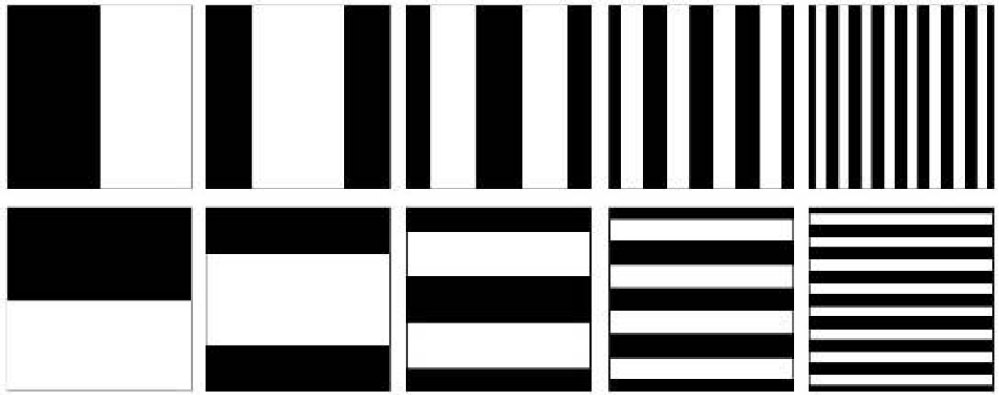


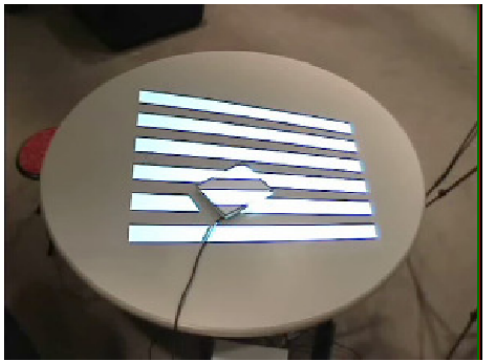


[UIST 2004]

Step 2:

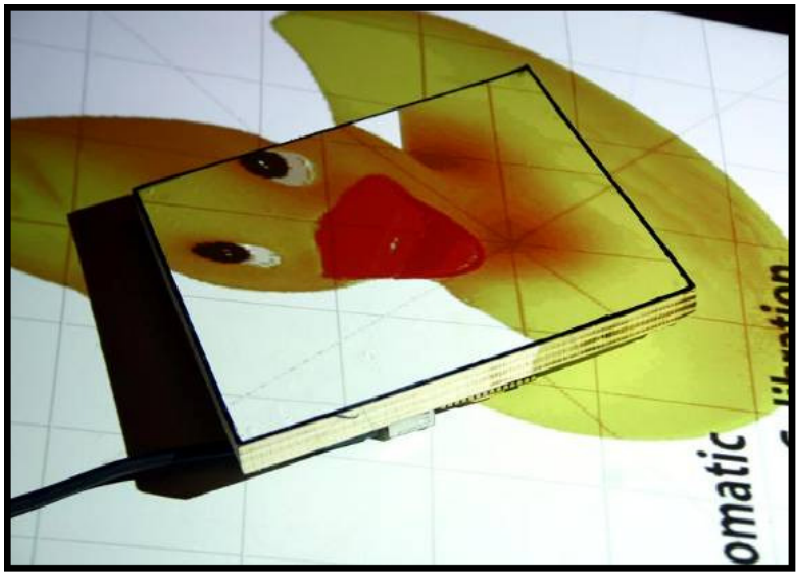
Project Gray-coded patterns

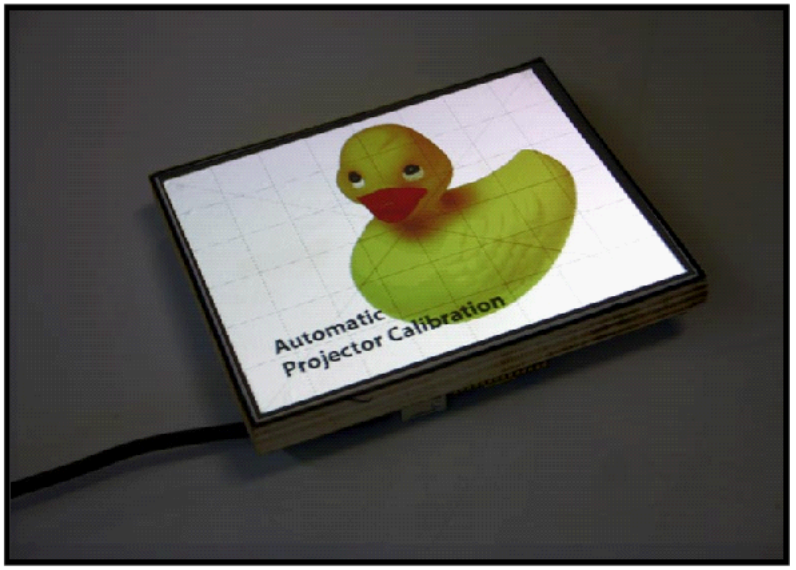




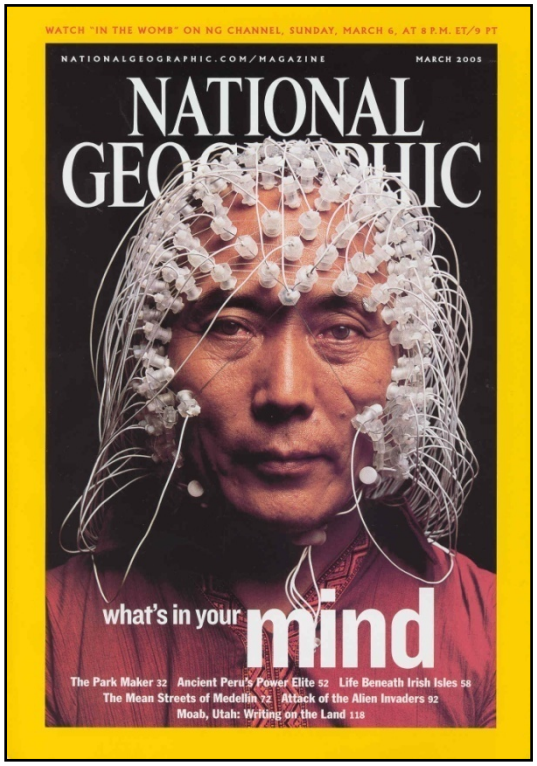
Step 3:

Decode location for application

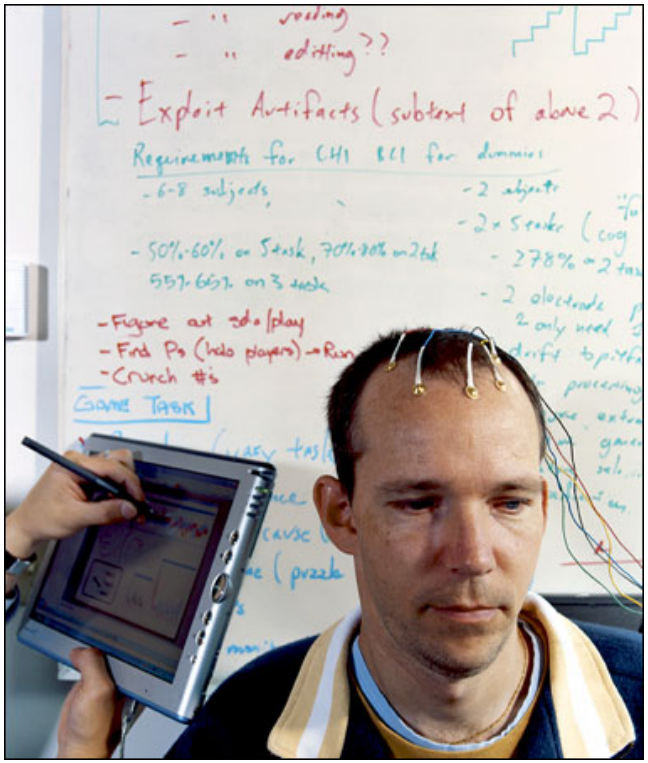




Low-Cost EEG
for Task Classification in HCI Research

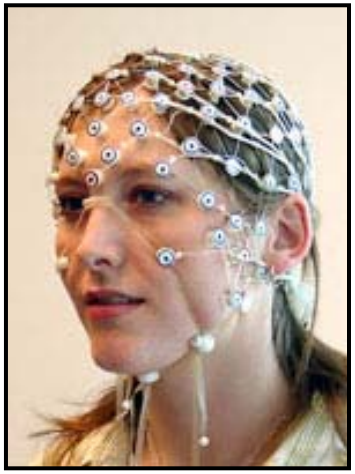


National Geographic, March 2005



NY Times Magazine, October 16, 2005

EEG Devices



Manufacturer: EGI Systems
Channels: 128-512
Cost: **$100K-$250K USD**

Manufacturer: BioSemi
Channels: 64-128
Cost: **~$30K USD**

The Brainmaster

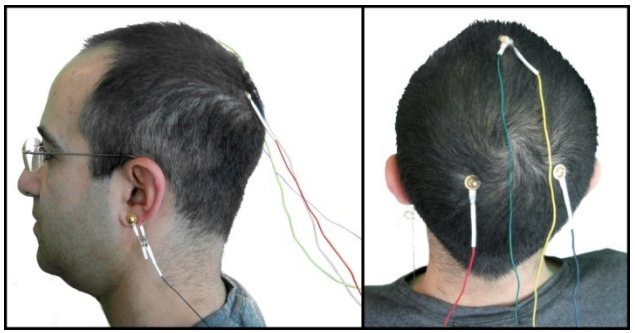
Lowest cost FDA approved device

Designed for home and small clinical use.

Only $1500 USD

Specs:

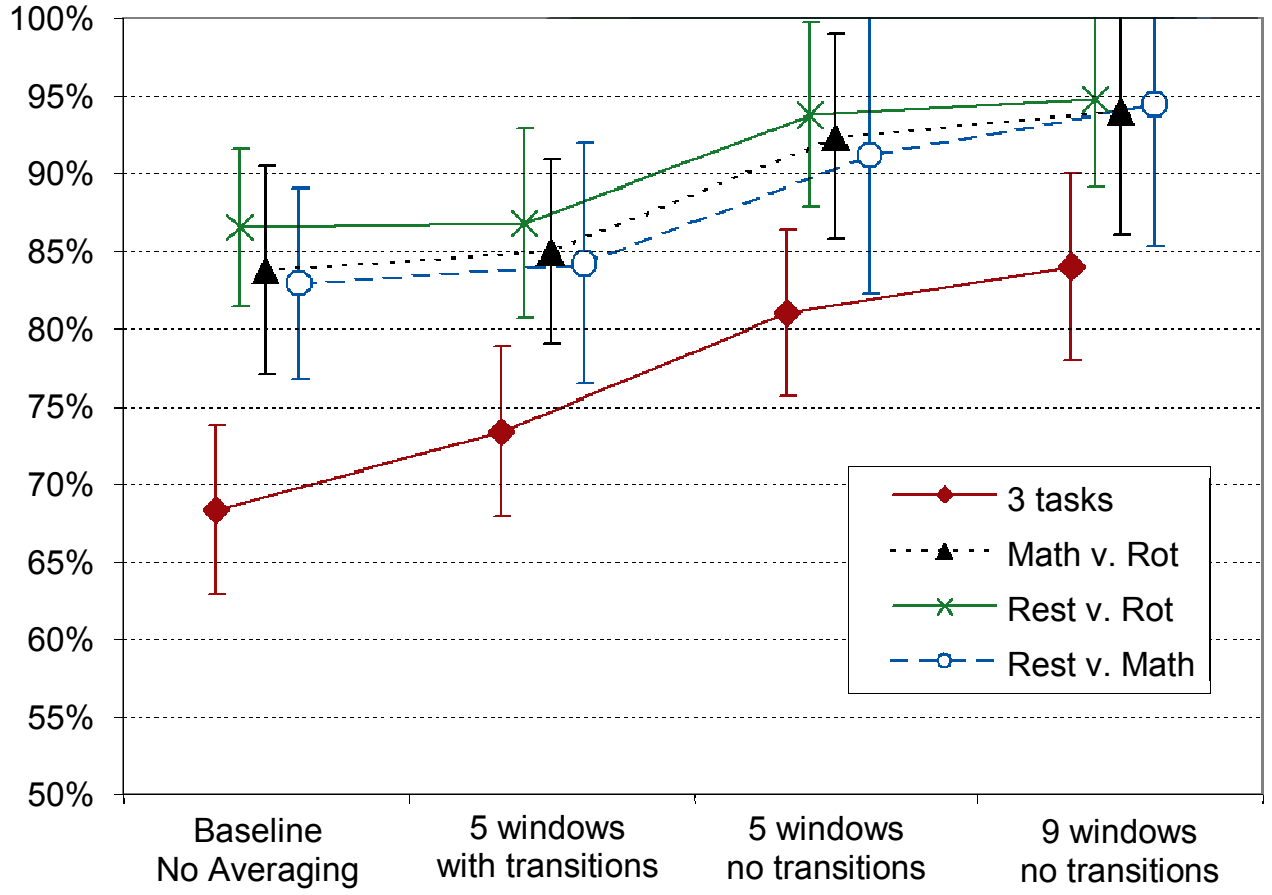
- 2-channels
- 8-bit at 4μV resolution
- 256 samples/sec



Needs to be validated for BCI research work.

If it works, it **lowers the entry bar** for BCI research.

Mean Classification Accuracy vs. Averaging Scenarios (Mental Tasks)

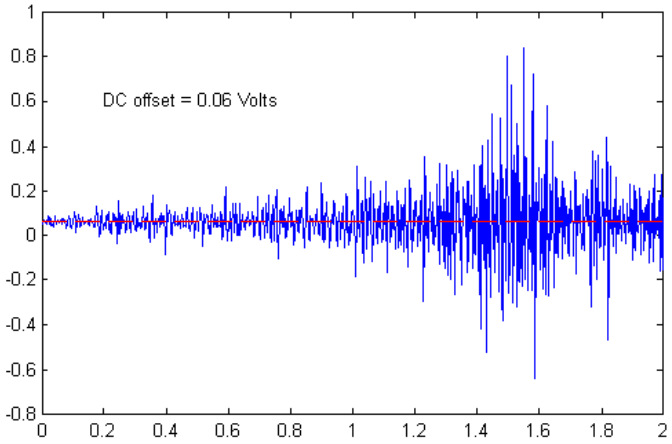


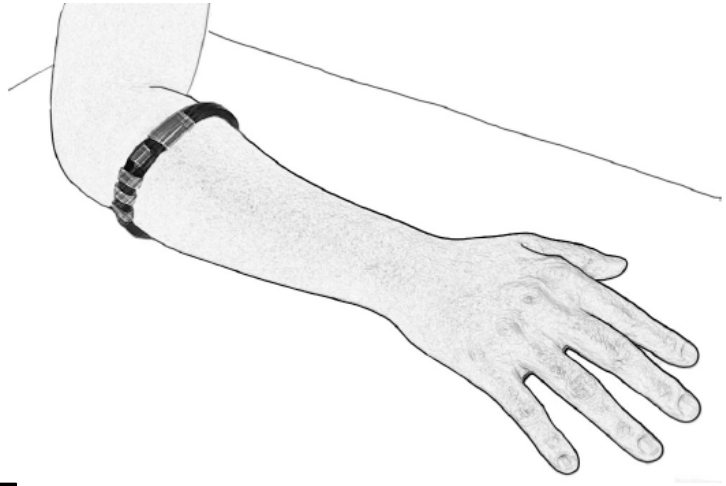
Error bars represent standard deviation

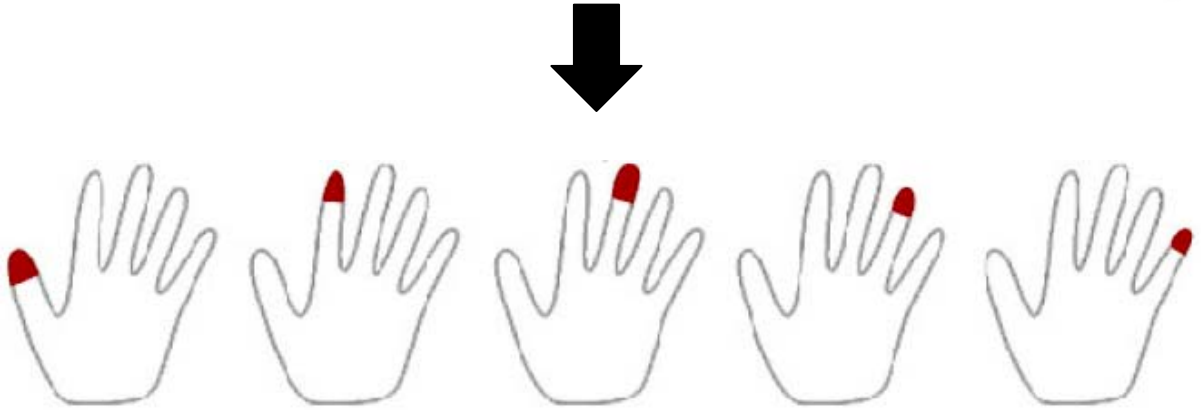
human as a sensor

HCII

Muscle-Computer Interfaces





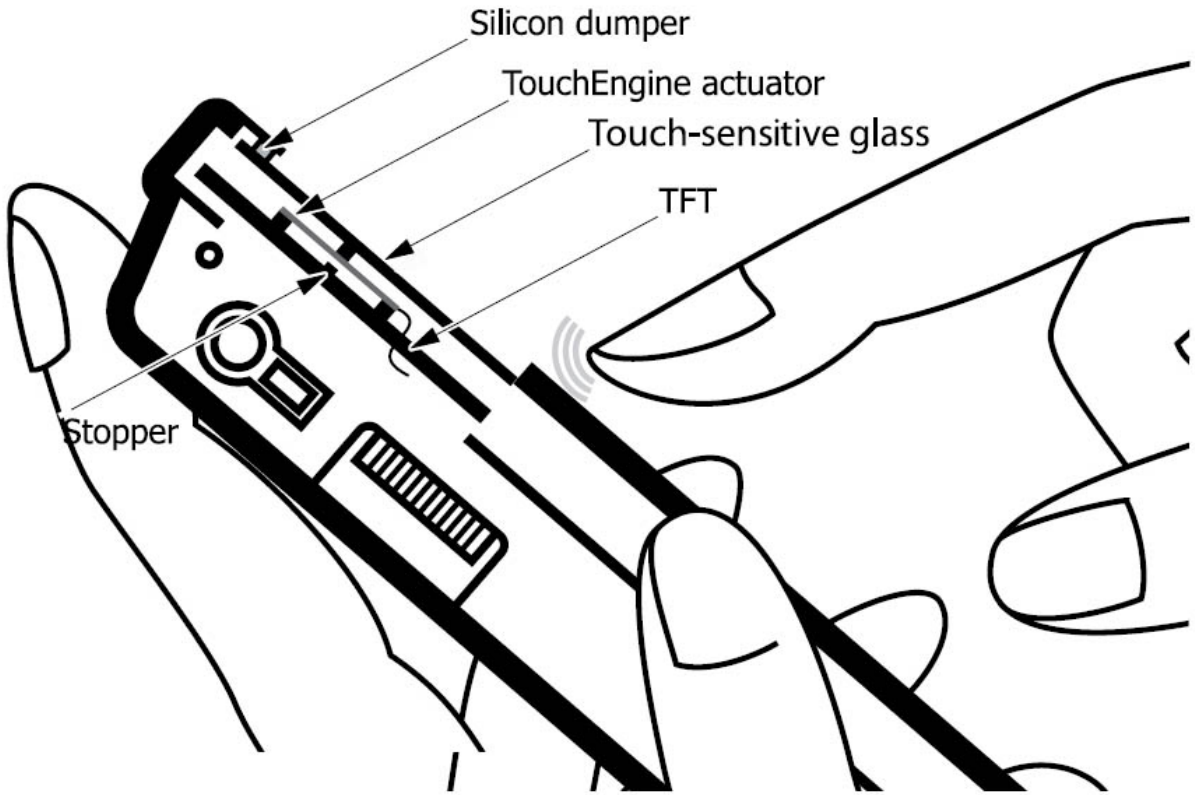


Pressure, Position, Tap, Lift

Haptic Pen (MERL - 2004)

Rob Tucker
Re: Jenny's Birthday
Great pl
Q W E R T Y U
A S D F G H J
Z X C V B N M
123
space
return

> $2000 USD



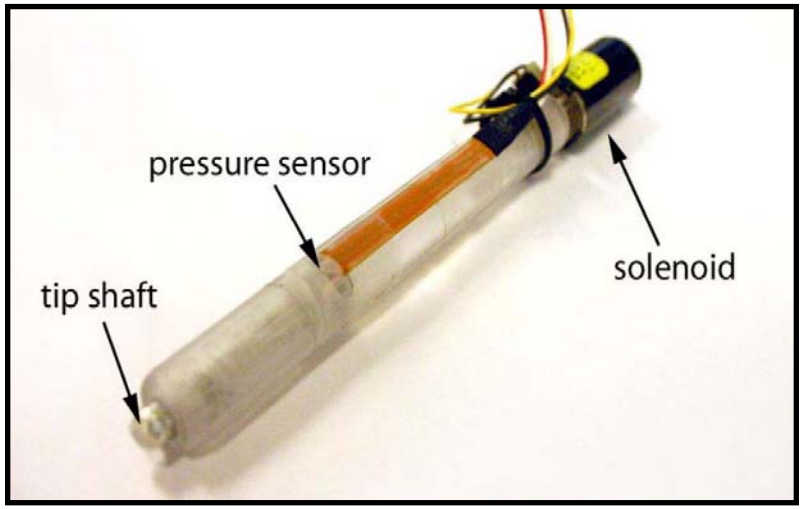
[Poupyrev and Maruyama, UIST 2003]

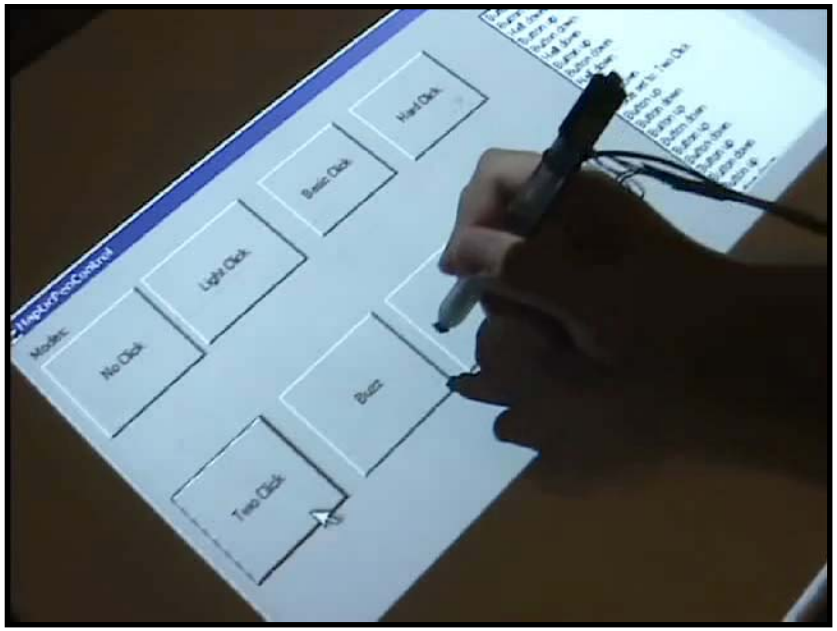
One touch, one person, small screens

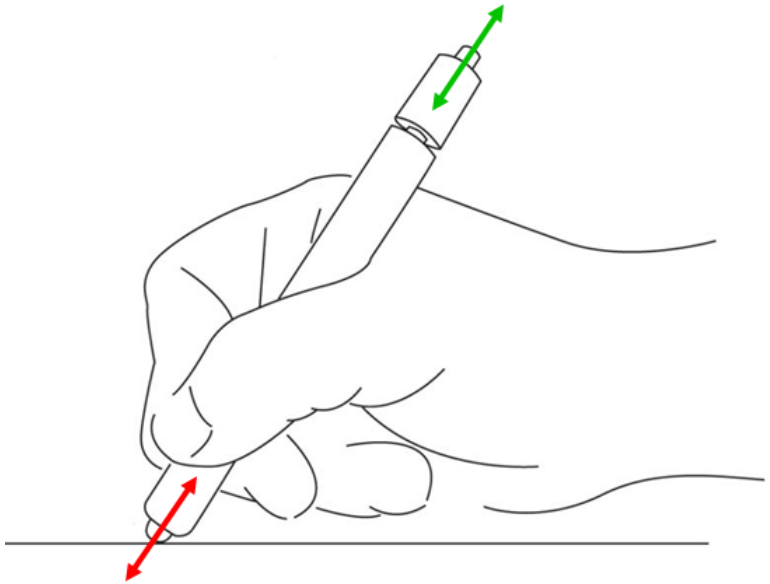
Goals: Support large touch-sensitive displays.
Support multiple simultaneous users.

Solution: Haptic Pen

- Individualized feedback
- Pressure Sensitivity
- Hover tracking data
- Feedback not bound to display
- Aftermarket device
- Low-cost (~$10)





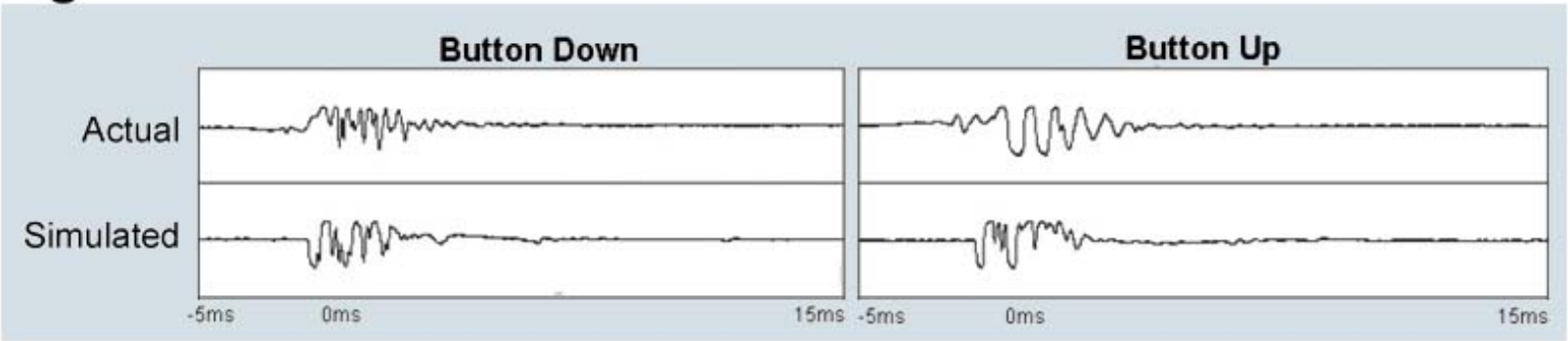


Pressure sensitivity allows variable feedback/activation

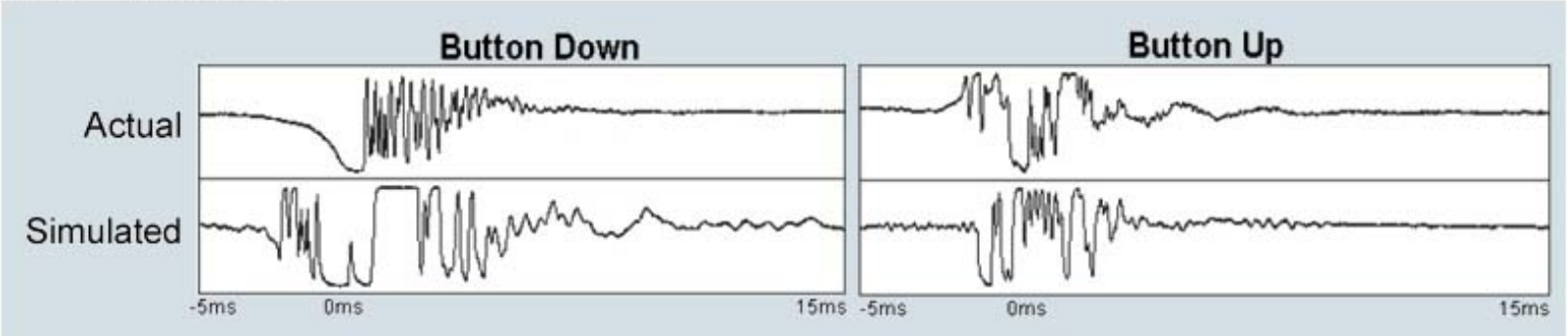
Multi-level buttons also possible (camera shutter)

On-axis feedback **more** accurate than vibration

Light Button



Stiff Button



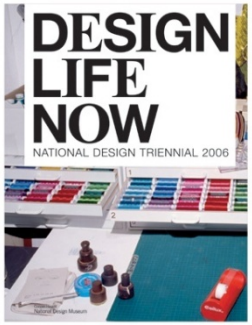
$14 Steadycam (2000)

$6000-$10,000

$14

Over **1.4M** views (not including syndication)
Over **$250K** in revenue

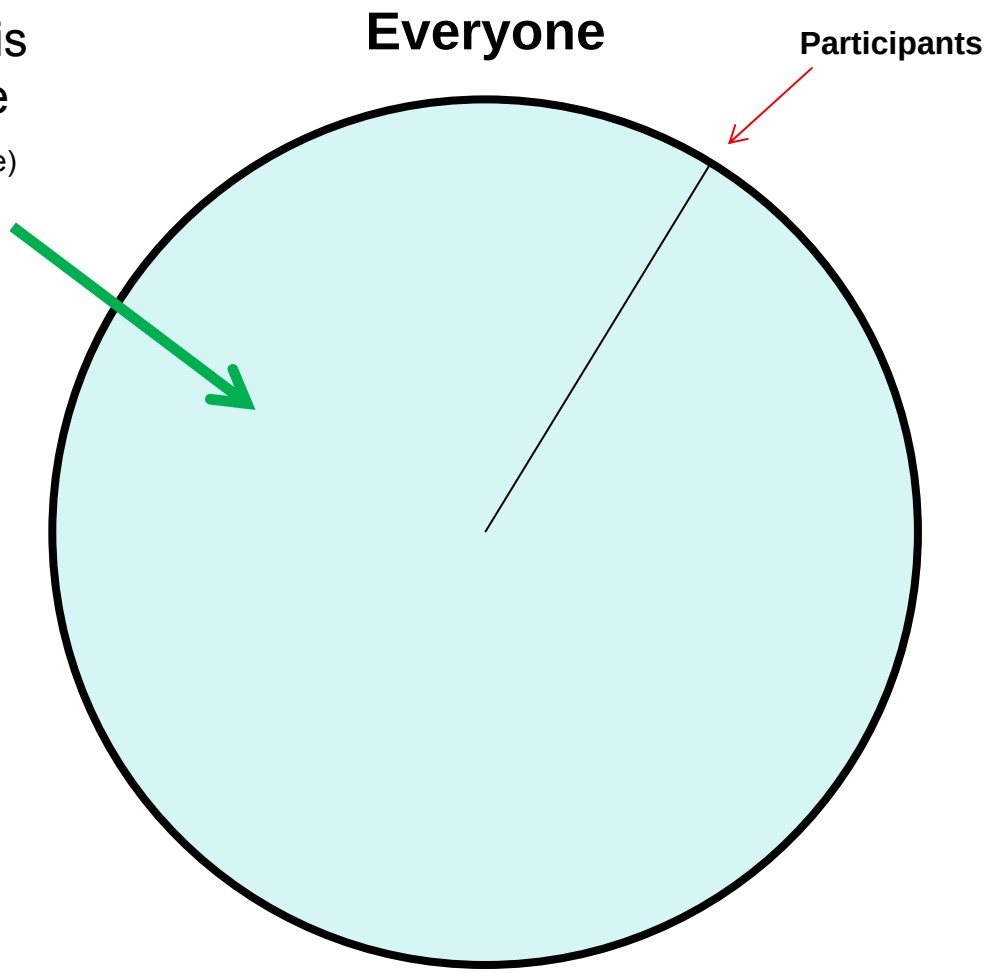
Staple of independent/student filmmaking community.
Used in many high-school and college programs.



If you create technology that is **accessible**, you can advance the state of humanity (if only a little)

2-3 orders of magnitude

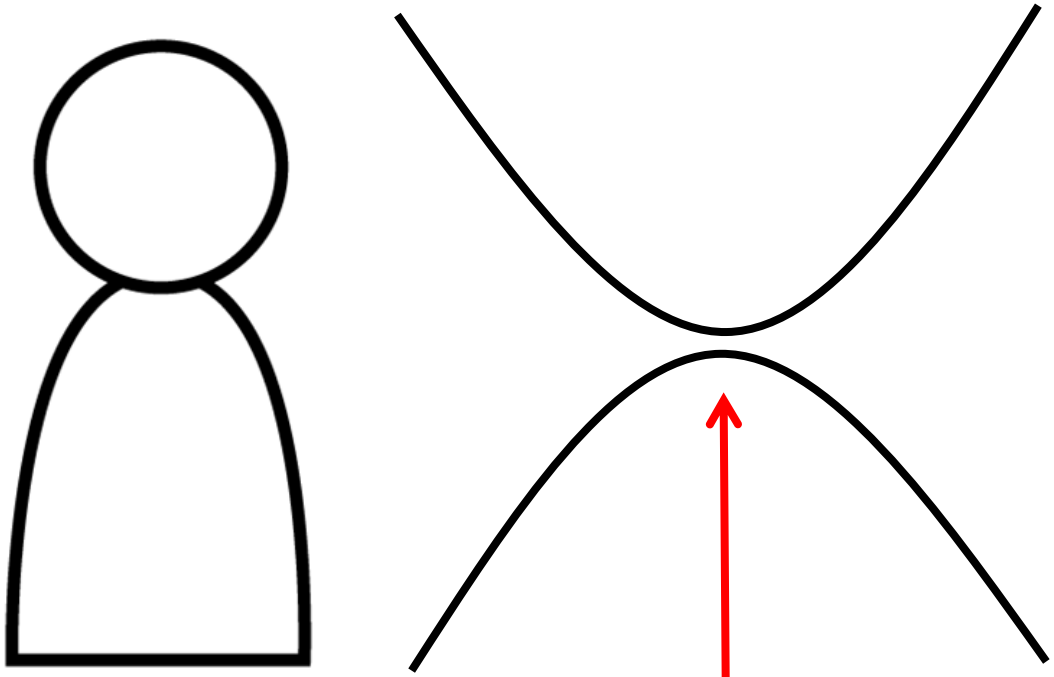
- Augmented reality
- Multi-touch surfaces
- Immersive Displays
- Brain-Computer Interfaces
- Haptics
- Filmmaking



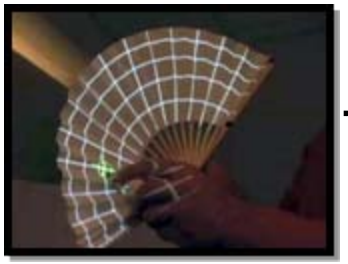
what next?

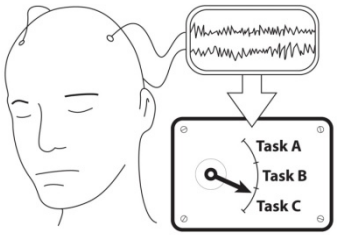
Star Trek – Next Generation, 24th century

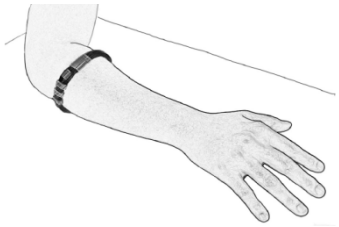
Crysis, EA, 2007



Immersion
Interactivity




Task A
Task B
Task C



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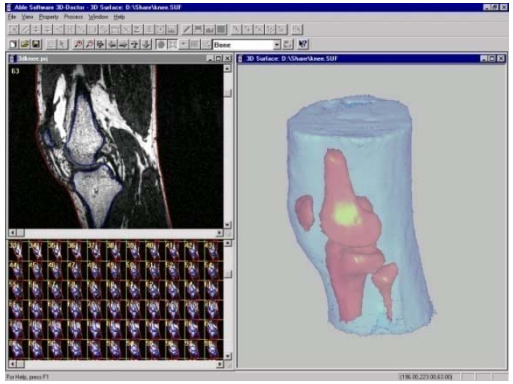
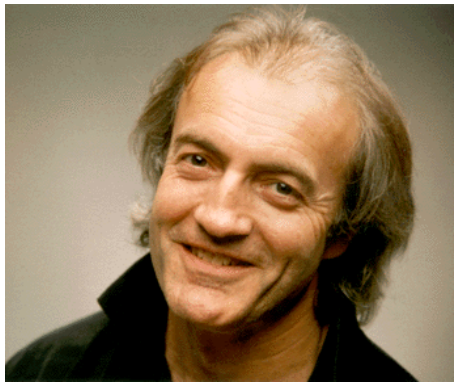


Jeff Han – FTIR/Perceptive Pixel

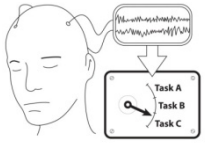
Andy Wilson – Surface/Xwand

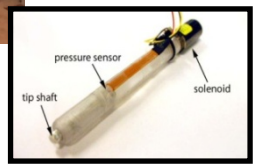
Paul Dietz – Diamond Touch/iPhone parent



Bill Buxton –Multi-touch/Maya/Alias

UIST – User Interface Software & Technology
Also consider: SIGGRAPH, SIGCHI, UBICOMP





Projector-Based Location Discovery and Tracking

Low-Cost EEG for Task Classification

Interaction Techniques using the Wii Remote

Haptic Pen

$14 steadycam

Collaborators: Desney Tan, Paul Dietz, Scott Hudson, Ramesh Raskar, Dan Maynes-Aminzade, Jay Summit, Chris Kyriakakis, Darren Leigh

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